APPENDIX F

Affidavit

State of Mississippi
County of Jackson

My name is George Sholl. I am an adult resident citizen of Jackson County Mississippi and I work as director for the Jackson County Emergency Communications District.

Sunday night before Hurricane Katrina made landfall I was working in the Emergency Operations Center (EOC) located in Pascagoula near the intersections of Convent and Magnolia Streets. I have marked the location of the EOC on the attached map.

The EOC is a 2 story building which had two anemometers and wind direction indicators. These instruments were part of the county's emergency operations center, they are professional type equipment and are accurate to the best of my knowledge. I have no reason to doubt the accuracy of those instruments.

Every so often while I was at the EOC, I observed the indicated wind speed and direction on the instrument. Before midnight wind speeds over 75 mph were indicated. The winds increased through the night and morning. Sometime in the morning after daylight I saw indicated wind speeds of 137 miles per hour generally out of the East. It was after I observed this that sections of the roof blew off of the EOC building and most of us then evacuated to the Courthouse. Some persons who remained in the EOC for a short time after that evacuation and I have heard that they observed indicated wind speeds of 140 mph. The tower blew down approximately 20 minutes after we left and no more readings were possible. The winds continued to increase and from what I saw, I believe that the winds after this must have been over 150 mph.

I cannot state the specific time I saw the indicated wind speed of 137 other than that it was after sun rise and before the tidal surge came into Pascagoula. The sequence of events was in this order: I saw indicated wind speeds of 137 miles per hour, after this roof sections blew off the EOC and we evacuated to the court house and after this the flood water came in over four more feet. When we evacuated the EOC, the flood water was just coming in.

I remember watching from the Courthouse as the water gradually came in and rose over four feet above the area I had walked through. There was never anything like a "tidal wave". I remember that as the water rose it flooded cars parked around us and car alarms went off and car trunks came open on their own. Understand that the maximum flood water level was marked on the side of the EOC building steps and that point was surveyed and found to be 16 feet above sea level.

The facts as stated in this affidavit are true and correct based upon my personal observations and knowledge unless otherwise stated.

George Sholl   18 Nov 05

George Sholl   Date

Personally appeared before me the undersigned authority in and for Jackson County, George Shoell who after first being sworn did state on oath that the facts and contained in this affidavit were true and correct. This the 18th day of November, 2005.

Patricia B. Byars

Notary Public

PATRICIA B. BYARS, JACKSON COUNTY, MS NOTARY PUBLIC

MISSISSIPPI STATEWIDE NOTARY PUBLIC
MY COMMISSION EXPIRES MAY 1, 2006.

APPENDIX G

APPENDIX G

DRAKE RESIDENCE RECONSTRUCTION ESTIMATE

95 LaBRANCHE AVENUE OCEAN SPRINGS, MISSISSIPPI

FROM

DAMAGES FROM HURRICANE KATRINA

I. Rebuild complete house using existing foundations and slab with addition of hurricane anchors, straps and tie-downs from foundations to roof structure.

Base cost per R. S. Means 2005 Residential Cost Data for Wood Frame/Brick Veneer - Luxury – 2 story construction (Reuse ground floor concrete slab for garage area)

Base Cost w/Basement	=	$ 117.80 per square foot
Upgrade Ceiling Finish	=	(+) 0.40 per square foot
Add for Heat Pump	=	(+) 2.29 per square foot
Total Base Cost	=	$ 120.49 per square foot
Heated & Cooled Living Area	=	5,512 S.F

Base Cost:

5,512 SF @ $120.49	=	$664,141

Upgrades & Adjustments:

Chimney & Fireplaces	=	$ 18,130
Upgrade Kitchen Cabinets	=	$ 35,000
Add full baths: 4 @ $8858	=	$ 35,432
Upgrade bath vanities: 5 @ $5,000	=	$ 25,000
Appliances	=	$ 35,000
Covered Porches:		
335 S.F. @ $62.85	=	$ 21,055
Finished Basement/Garage		
2,410.8 S.F. @ $50.00	=	$120,500

Patio: 168 S.F @ $35.00	=	$ 5,880
Reconstruct Lawn & Landscaping Allow	=	$ 50,000
TOTAL ESTIMATED RECONSTRUCTION TOTAL	=	$1,001,138

2. Alternative Cost Estimate for cost of interior heated and cooled living area.

The house was a luxury home with exquisite appointments throughout and the $120.49 per square foot estimate shown in Means would not be nearly enough to rebuild this luxurious home. It is commonly reported on the Gulf Coast that $140.00 to $175.00 per square foot costs are being quoted by contractors at the present time for reconstruction of custom homes. Since this house was such a luxuriously constructed house, I believe that a reasonable base cost estimate for reproducing the quality of construction of this house could be as much as $175.00 per square foot at the present time. Therefore, I modify the estimate above based on the R. S. Means unit cost as follows.

Heated and Cooled Living Area = 5,512 S.F

Estimated Reconstruction Cost:

5,512 S.F. @ $175.00	=	$964,600

Increase in estimated cost by alternative pricing:

$964,600 – 664,141	=	$300,459

Alternative Total Cost Estimate

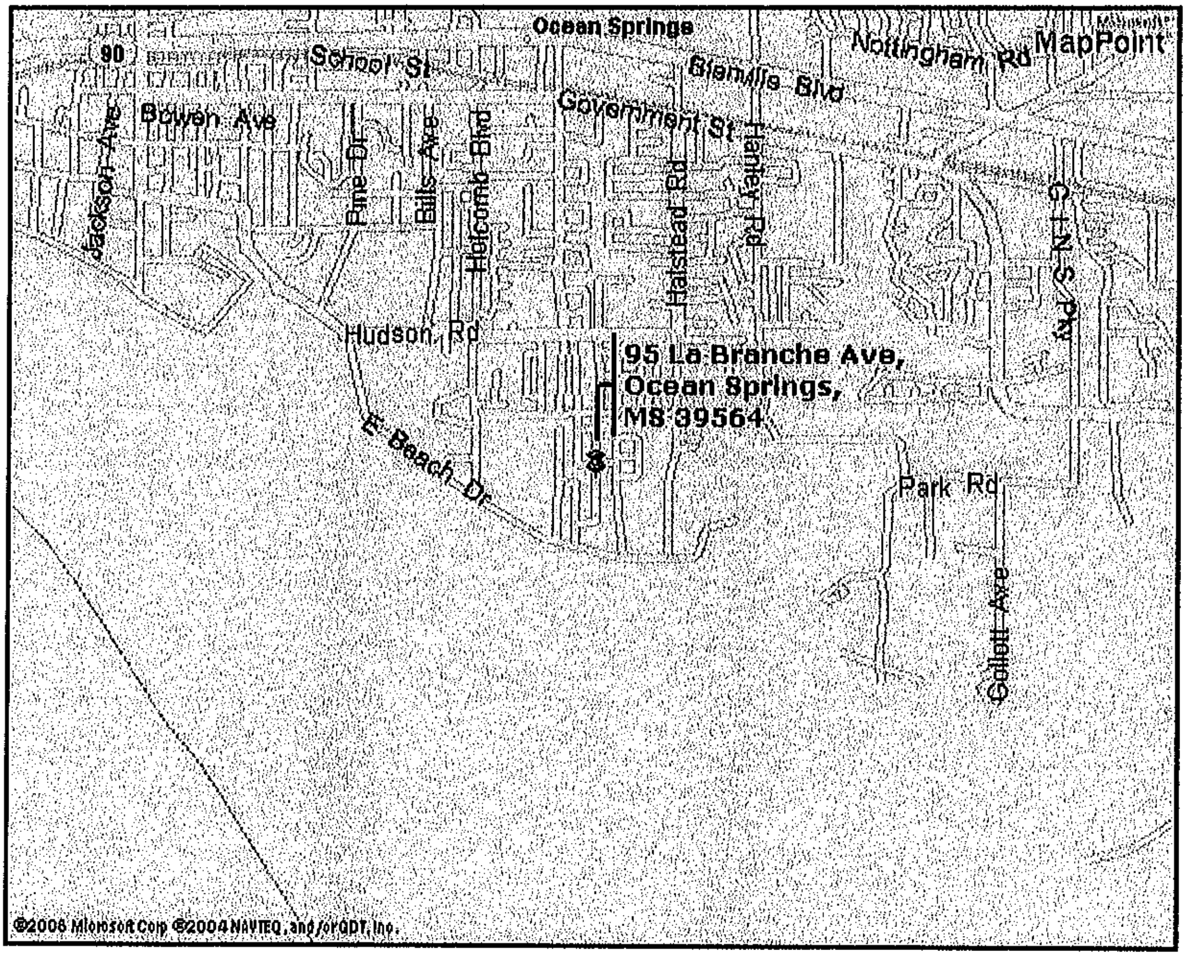
$1,001,138 + $300,459	=	$1,301,597

APPENDIX H

msn Maps & Directions

Featuring Microsoft® MapPoint® Technology

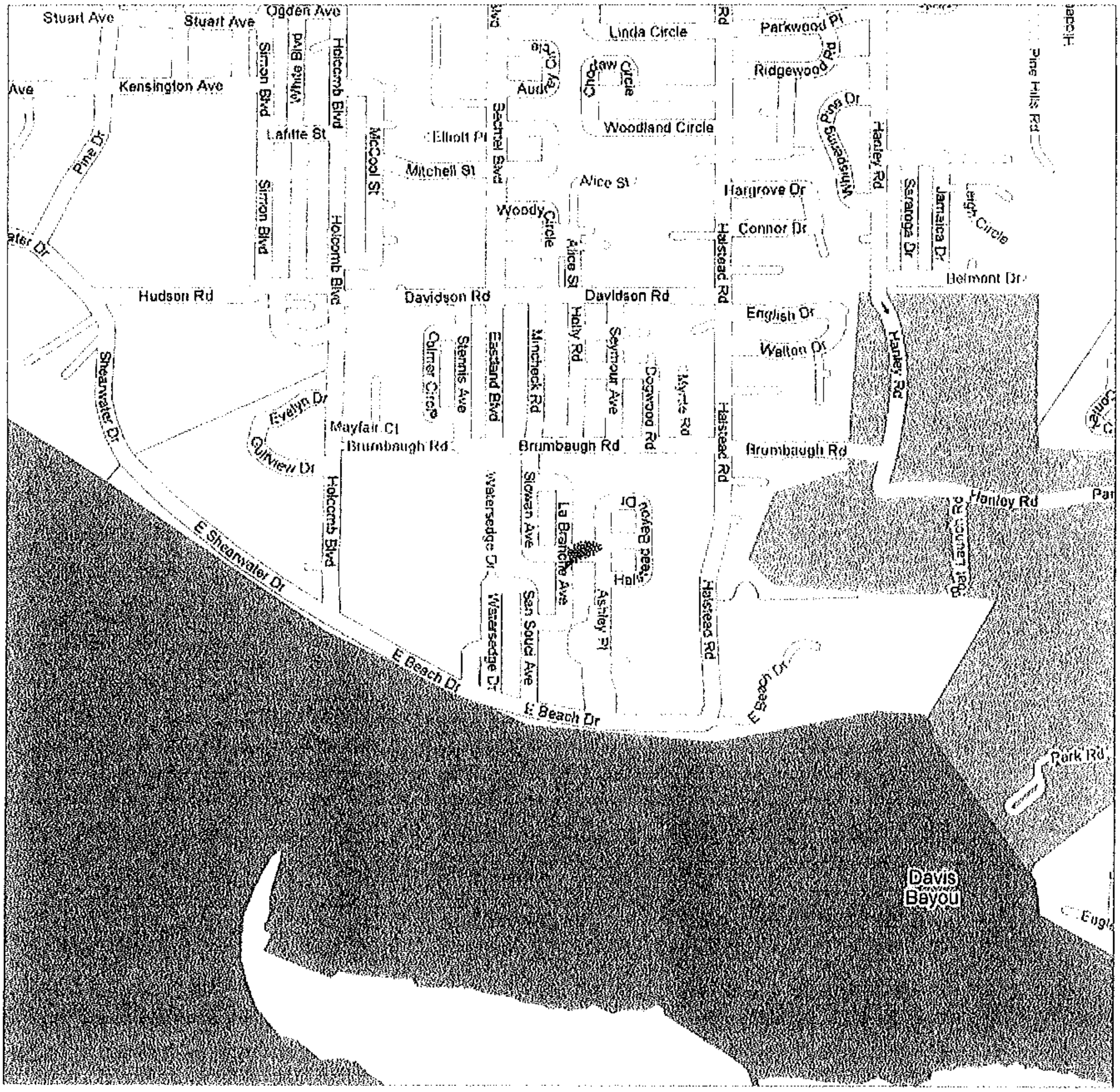
95 La Branche Ave, Ocean Springs, MS 39564



Your right to use maps and routes generated on the MSN service is subject at all times to the MSN Terms of Use.
Data credits, copyright, and disclaimer.

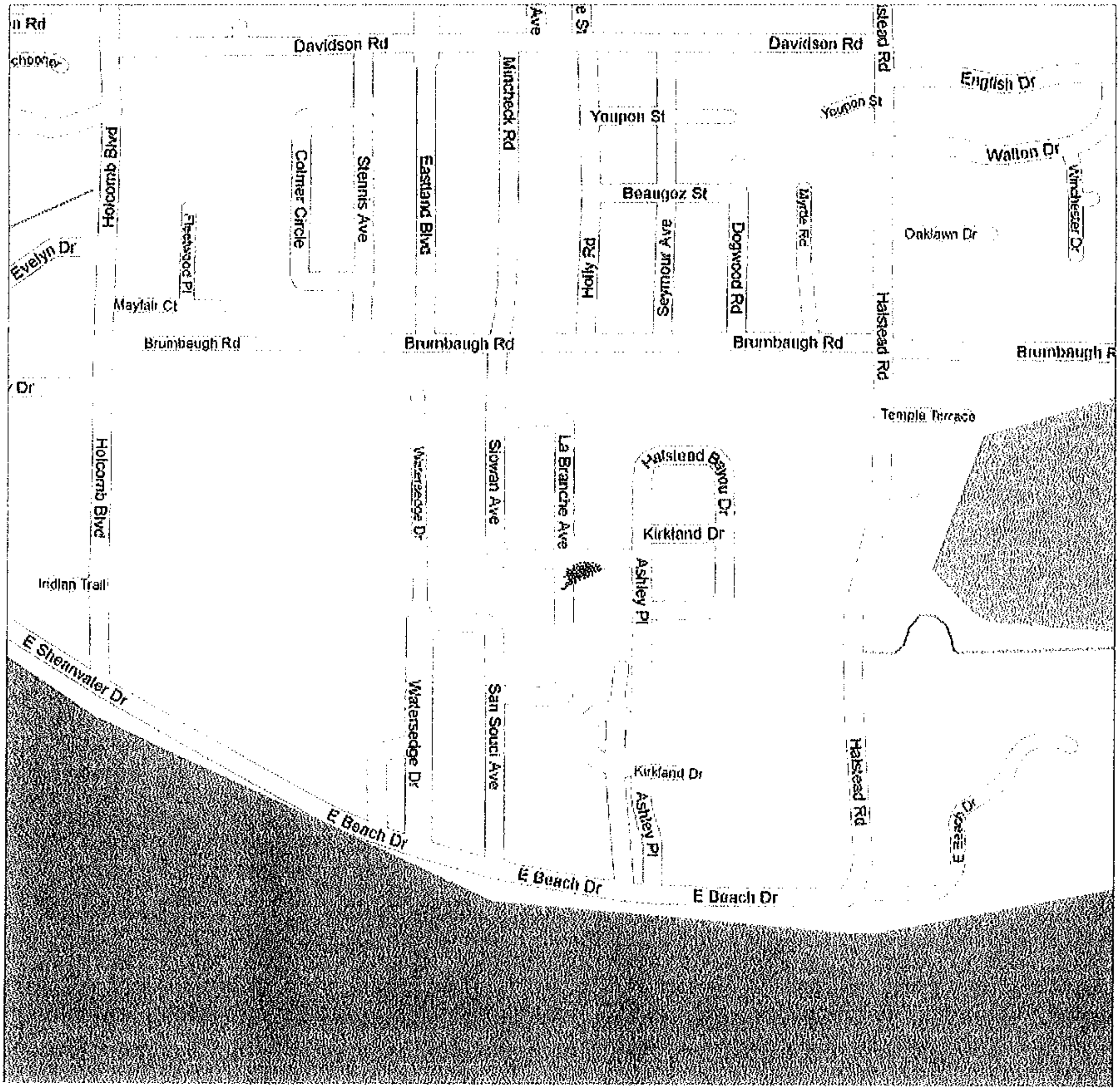
Google Maps

Address **95 La Branche Ave**
Ocean Springs, MS 39564



Google Maps

Address **95 La Branche Ave**
Ocean Springs, MS 39564



APPENDIX I

David Beale
PO Box 675
Ocean Springs, MS 39566
228-323-2655

To Whom It May Concern:

This is to confirm that I was present in the home at 106 San Souci Ave., Ocean Springs, Mississippi when Hurricane Katrina tore the structure apart. It is a fact that while water came in the bottom of the home, the wind took off the south end of the roof and the patio roof on the west side of the home. I had to evacuate the home to the roof of a neighboring home and am not aware of the further damage to the home as it was happening. I did see other roofs in the neighborhood such as the residence of Jerry Platt at 102 San Souci Ave be lifted by the wind before the water reached it. It is my opinion that the devastation to these homes was the result of a combination of wind then water.

Regards,

David Beale

KEITH SAWYER
My Comm. Exp. 01/13/08
Notary I.D. 1026278
DD281050

04NOV05

PERSONALLY KNOWN

APPENDIX J

ACCU WEATHER®
The World's Weather Authority™
385 Science Park Road, State College, PA 16803-2215
814-235-8626 fax: 814-235-8769
e-mail: forensics@accuwx.com Forensics.AccuWeather.com

May 3, 2006

Attorney Paul S. Minor, P.A.
160 Main Street
P.O. Drawer 1388
Biloxi, MS 39533

RE: Katrina
AccuWeather File Number: 030646

Dear Mr. Minor:

As you requested, we have investigated the weather conditions at 100 Holcomb Boulevard, Ocean Springs, Jackson County, Mississippi during Hurricane Katrina on August 29, 2005, with particular attention to a timeline of wind and storm surge along with other related issues. The results of our investigation are presented in the following paragraphs and tables. The CD that accompanies the report includes a graphic representation of the wind/surge timeline and color Doppler radar images.

SOURCES OF INFORMATION

The following sources of data and information were used in the preparation of this report:

1) *Tropical Cyclone Report - Hurricane Katrina*, published by the National Hurricane Center on December 20, 2005.
2) *Hurricane Katrina – A Climatological Perspective*, Preliminary Report; Technical Report 2005-01, published by the National Climatic Data Center in October 2005.
3) *Hurricane Katrina and Its Aftermath*, by Patrick J. Fitzpatrick, Y. Lau, S. Bhate and Y. Li, prepared in January 2006 as Chapter 3 of *Coast in the Eye of the Storm – Hurricane Katrina: August 29, 2005*, a technical report by the Mississippi State University College of Engineering, edited by W. Mcanally.
4) *The Intensity of Wind Gusts Underneath Areas of Deep Eyewall Convection in Hurricanes Katrina and Dennis at Landfall*, by Richard G. Henning, 46th Weather Squadron, Eglin Air Force Base, Florida, presented at the American Meteorological Society's 27th Conference on Hurricanes and Tropical Meteorology in April 2006.
5) *A WSR-88D Assessment of Tropical Cyclone Outer Rainband Tornadoes*, by Scott M. Spratt, David W. Sharp, Pat Welsh, Al Sandrik, Frank Alsheimer and Charlie Paxton, all of the National Weather Service; published in <u>Weather and Forecasting</u>, a journal of the American Meteorological Society, in 1997.
6) Surface wind analyses of Hurricane Katrina for selected times on August 29, 2005, produced by the Hurricane Research Division of the National Oceanic and Atmospheric Administration.

7) Hourly surface weather observations for August 28 and 29, 2005 from airports in Bay St. Louis, Biloxi and Pascagoula, Mississippi, taken by the National Weather Service and the Federal Aviation Administration.
8) Wind data from observation sites in Bay St. Louis and Pascagoula, Mississippi, operated by universities and private sources, including Texas Tech University, the University of Florida and Florida International University.
9) Storm surge data for August 29, 2005 from observations sites in Waveland and Horn Island, both in Mississippi and Dauphin Island, Alabama, taken by the National Ocean Service.
10) Initial Hurricane Katrina Landfall Wind Speed Estimates prepared for the Federal Emergency Management Agency by Applied Research Associates, Inc.
11) Post-Tropical Cyclone Report for Hurricane Katrina prepared by the National Weather Service Forecast Office in New Orleans, Louisiana.
12) Hurricane Katrina Tornado Warnings and Eye-Wall Warnings issued by the National Weather Service Forecast Office in New Orleans, Louisiana on August 29, 2005.
13) Hurricane Katrina Cumulative Rainfall Stage III Multi-Sensor Precipitation Estimate issued by the National Weather Service Southern Region Headquarters.
14) Storm reports for August 29, 2005, issued by the National Weather Service Storm Prediction Center.
15) Base reflectivity data, mesocyclone and tornado vortex signature data for selected times on August 29, 2005 from the National Weather Service Doppler radars in Mobile, Alabama and Slidell, Louisiana.
16) Mississippi Hurricane Katrina Surge Inundation and elevation maps issued in November 2005 by the Federal Emergency Management Agency.
17) Aerial photographs of Mississippi coast damage areas taken by the National Oceanic and Atmospheric Administration within a few days after August 29, 2005.
18) Personal visits to 100 Holcomb Boulevard, Ocean Springs, Mississippi and nearby locations by Stephen Wistar, CCM on December 2, 2005, January 6 and 7, 2006, and April 9 and 12, 2006.
19) First-hand reports from dozens of individuals along the Mississippi coast who did not evacuate and thus were eyewitnesses to Hurricane Katrina, including eight in Ocean Springs.
20) Wind and surge data for Ocean Springs from the Advanced Circulation (ADCIRC) model, made available by WorldWinds, Inc. in April 2006.
21) Personal communication with Ted L. Biddy, P.E., P.L.S.
22) Personal communication with Chris J. Peterson, Ph.D., Associate Professor of Plant Biology at the University of Georgia.
23) Personal communication with Gregory Forbes, Ph.D., severe weather expert at the Weather Channel.
24) Report on the Fujita Scale Enhancement Project, submitted to the National Weather Service by the Wind Science and Engineering Center of Texas Tech University in June 2004.

OVERVIEW OF HURRICANE KATRINA

Hurricane Katrina ranks as one of the worst natural disasters in the history of the United States. The death toll from the storm is the highest in the country since 1928 and the total damage cost is far above that of Hurricane Andrew in 1992, which had been the costliest natural disaster in the nation's history.

Katrina began its life as Tropical Depression Twelve on August 23, 2005 over the southeastern Bahamas. The system strengthened into Tropical Storm Katrina the next day as it moved through the central Bahamas. The storm reached minimal Category 1 strength on the Saffir-Simpson hurricane scale on August 25, 2005 just before making its first landfall near North Miami Beach, Florida. During that night, Katrina weakened only slightly while moving west-southwestward across the southern Florida Peninsula and caused substantial damage, flooding and eleven deaths. The following table shows the Saffir-Simpson hurricane scale.

STORM CATEGORY	PRESSURE (millibars)	PRESSURE (inches)	SUSTAINED WINDS (mph)
1	980 to 1000	28.93 to 29.53	74 to 95
2	965 to 979	28.49 to 28.92	96 to 110
3	945 to 964	27.90 to 28.48	111 to 130
4	920 to 944	27.17 to 27.89	131 to 155
5	Less than 920	Less than 27.17	156 and up

Once the storm moved back over water in the southeastern Gulf of Mexico, atmospheric and oceanic conditions were very conducive to strengthening and Katrina attained major hurricane status, Category 3, on the afternoon of August 26, 2005. The strengthening continued on August 27 as the storm moved westward and was accompanied by a dramatic expansion outward of hurricane-force winds. Katrina nearly doubled in width on the 27th, resulting in a large hurricane of a size most commonly seen in western Pacific Ocean typhoons.

Hurricane Katrina turned toward the northwest into the central Gulf of Mexico on August 28, 2005 and, after a period of explosive deepening over the warmest water in the Gulf, reached its maximum Category 5 strength that morning while the center of the storm was located nearly 200 miles southeast of the mouth of the Mississippi River. Peak sustained winds at that time were estimated at 172 MPH. The barometric pressure in the eye fell to its minimum of 902 millibars (26.64 inches) on the afternoon of the 28th. At the time, this was the 4th lowest pressure on record for an Atlantic basin hurricane. However, Hurricanes Rita and Wilma had even lower barometric pressures during their lifetimes and pushed Katrina into 6th place by the end of the 2005 hurricane season.

Early on August 29, 2005, Hurricane Katrina turned northward toward the Mississippi River Delta and then made landfall near Buras, Louisiana at 6:10 a.m.[1] At 9:45 a.m., the eye of Katrina was making its second Gulf coast, and final overall, landfall near the mouth of the Pearl River on the Louisiana-Mississippi border.

There was a significant change in the structure of Katrina from August 28 to August 29 as it moved steadily northward toward the Gulf coast. On Sunday the 28th, when the storm was at its peak strength over the warmest waters of the Gulf of Mexico, the strongest winds were concentrated near the center. As the storm pulled in some dry air from its western side while at the same time encountering lower oceanic heat content close to the coast, the inner eyewall weakened before landfall on the morning of Monday the 29th while at the same time there was a strengthening of winds 30 to 50 miles east of the center, especially above the surface. Thus, there was a spreading out of the winds and the storm remained unusually large in areal extent. Since the highest sustained winds of a hurricane, usually found in or near the eyewall, determine the official strength in terms of its category, Katrina was officially downgraded before landfall. There is currently some controversy regarding the strength of Katrina at landfall. The official final report from the National Hurricane Center lists it as a Category 3 at that time with maximum sustained winds of about 125 MPH at the first Gulf landfall near Buras, Louisiana and 120 MPH at the second Gulf landfall near the Louisiana/Mississippi border. The pressure at the first landfall was 920 millibars (27.17 inches) and the pressure at the final landfall was 928 millibars (27.40 inches). Thus, even though peak sustained wind speeds at landfall were at Category 3 intensity, the barometric pressure of the storm remained at strong Category 4 intensity.

Despite the overall weakening of Hurricane Katrina prior to landfall, it was still a major and very large hurricane when it came onshore. Bands of intense convection[2], both in the eyewall and in rain bands outside the eye, brought strong winds aloft down to the ground in fierce gusts, triggering scattered tornadoes and downbursts. Areas of severe damage resulted from these localized bursts of wind, many of which occurred along the Mississippi coast prior to the final landfall.

Hurricane Katrina also brought a severe storm surge to the Gulf coast from eastern Louisiana to western Alabama, including the entire Mississippi coast. In Mississippi, the surge rose rapidly one to two hours before Katrina's final landfall at the mouth of the Pearl River and peaked within an hour or so after that landfall, causing widespread damage in coastal cities and towns. The surge was highest along the western part of the Mississippi coast where the eye of the storm made landfall.

Heavy rainfall accompanied Hurricane Katrina along the entire Mississippi coast, with estimated amounts ranging from 5 to 10 inches.

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[1] This and all other time references in this report are expressed in Central Daylight Time (CDT).

[2] Convection in the atmosphere, usually manifested in the form of thunderstorms, contains strong rising and sinking currents of air. Convection can result in strong wind gusts at the ground as higher velocity air aloft is directed downward by sinking currents of air.

Inevitably, comparisons have been drawn between Hurricane Katrina and Hurricane Camille, which made landfall in nearly the same location in August 1969. Camille was more intense than Katrina at the time of landfall but covered a much smaller area. At the time of landfall, the eye of Camille was 11 miles across while the eye of Katrina was approximately 35 miles wide. Thus, the powerful winds in and near the eyewall affected a much larger area with Katrina than with Camille. Hurricane force winds with Katrina extended 120 miles out from the storm's center, twice as far as Camille's winds. Katrina was moving slower than Camille when coming onshore, causing a longer period of wind exposure and increasing the height of the storm surge.

In the following sections of this report, we discuss hurricane wind and storm surge characteristics in more detail, including details specific to Katrina. We present our methodology for determining the timing of wind and storm surge details for a given location. Then, we present a timeline of the wind direction and speed along with the height of the storm surge for 100 Holcomb Boulevard in Ocean Springs during Hurricane Katrina. A summary and conclusions follow.

WIND CHARACTERISTICS OF HURRICANES

Hurricane intensity is defined by <u>sustained winds</u> and not the strength of short-lived wind gusts. Officially, for Atlantic basin hurricanes, sustained winds represent the average speed over a one-minute period at a height of 10 meters (33 feet) above the surface. The intensity of a storm is determined by the strongest sustained winds that can be found in any portion of the circulation of the storm, with the speed being adjusted to the 33-foot height by a mathematical relationship that describes how wind speed normally varies with changing height above the surface.

In reality, the speed of the wind at a given location in a hurricane is constantly changing due to a variety of factors, including turbulence, convective downdrafts and frictional effects over land where there is more disruption of the airflow than over water. These effects cause frequent wind gusts, which are sudden, brief increases in speed for a period of several seconds. With all other factors being equal, sustained wind speeds will be lower over land than water, but the percentage increase in wind speeds during gusts will be higher over land due to turbulent eddies. Research has shown that, over water, the speed of wind gusts will typically be about 25 percent higher than sustained wind speeds. Over flat land with no obstructions, the strength of gusts will average a 35 percent increase over sustained wind speeds. In the lowest part of the atmosphere over forested and urban areas, the sustained winds are slowed substantially compared to over water, but the gust factor increases to 65 percent as the still strong winds aloft penetrate down to the ground at times. In a hurricane, these wind gusts are responsible for a significant portion of the wind-induced damage to buildings and trees.

Localized even stronger wind impacts can occur in hurricanes, primarily where convection is concentrated in the eyewall and in rain bands outside the eye. In these locations, downbursts or tornadoes can take place over relatively small areas, usually in swaths that are no more than a mile or two long and less than a mile wide. A downburst results from a strong downdraft that

hits the ground and then spreads out horizontally. Enhanced surface winds in a hurricane downdraft blow generally in a straight or slightly curving path.

Tornadoes occur within most major land-falling hurricanes. Research has revealed the following circumstances are most highly correlated with tornadoes:

1) Tornadoes are most common in the right front quadrant of the storm at landfall.
2) Tornadoes are most common near the hurricane core within 60 miles of the eye on the day of landfall.
3) Large hurricanes produce more tornadoes than small hurricanes.
4) More intense hurricanes produce more tornadoes than less intense storms.
5) The optimal forward speed of a hurricane for tornado production is between 8 and 33 MPH.
6) Tornadoes are far more common with hurricanes making landfall from the Gulf of Mexico than with those making landfall from the Atlantic Ocean.
7) Tornadoes are affiliated with discrete, small but intense precipitation echoes on radar, especially when these echoes are part of an organized, persistent rainband. On National Weather Service Doppler radar (NEXRAD) images, the intensity of the color-coded echoes is measured in dBZ's (decibels of "Z", which is a reflectivity factor). Research has shown that the echoes must have a minimum intensity of 50 dBZ to be considered as a possible tornado-producer.
8) Many of the tornadoes with land-falling hurricanes occur very near the coast due to impacts on the airflow as it encounters increased and varied frictional effects when blowing from water to land.
9) There are also tornado-like vortices that are often found in the eyewall of the hurricane itself. The eyewall of Katrina remained to the west of Ocean Springs.

OBSERVATIONS OF TORNADO AND DOWNBURST DAMAGE IN COASTAL MISSISSIPPI WITH HURRICANE KATRINA

All nine of these characteristics were present along the Mississippi coast with Hurricane Katrina. Indeed, during our travels along the entire length of the coast, we witnessed numerous concentrated damage swaths due to wind. Some of these swaths showed evidence of straight-line wind damage and others showed evidence of tornado damage. There is no official record of tornadoes or downbursts in the three Mississippi coastal counties with Katrina. Normally, the National Weather Service will conduct field surveys following a hurricane to document tornado or downburst paths. However, this was not done following Hurricane Katrina, probably due to problems the New Orleans office of the National Weather Service was having after being forced to relocate their operation to Lake Charles, Louisiana for a lengthy period following the storm. We believe that in actuality there were dozens, if not over one hundred separate downbursts or tornadoes in southern Mississippi on the morning of August 29, 2005 when Hurricane Katrina made landfall. Additionally, because of the large size of the storm, locations throughout the Mississippi coast were exposed to hurricane-force wind gusts for many hours.

STORM SURGE WITH HURRICANES

All land-falling hurricanes have a storm surge that is caused by the force of the wind driving water toward the coast. The surge from a hurricane is very different from a tsunami in that the surge arrives as a steadily rising level of water rather than as a large wave. There is always some wave action along the immediate coast with the storm surge, but as the surge moves inland the waves are damped out by obstacles such as trees and buildings. Both the surge and accompanying waves can cause major damage. The following factors play a role in the elevation attained by the storm surge with a hurricane:

1) The stronger the winds in a hurricane, the higher the level of the storm surge.
2) A hurricane that covers a large area will in general have a higher storm surge than a storm with a small areal extent.
3) The lower the atmospheric pressure (weight of the atmosphere) in the storm, the more the water will expand upward. The water level rises 3.9 inches for every 10-millibar drop in the hurricane's central pressure.
4) A shallow offshore shelf will force a storm surge to pile up on itself and attain a higher level than if the shelf drops off rapidly near the coast.
5) Larger waves arriving at the coastline will propel the surge further inland than smaller waves.
6) The angle at which the storm approaches the coast influences the height of the surge. The surge is highest when a storm makes landfall perpendicular to the coast.
7) The surge is highest on the right side of the place of landfall where the winds are blowing onshore.
8) The background tides affect the surges height. A surge arriving at high tide will have a higher elevation than at low tide.

STORM SURGE WITH HURRICANE KATRINA

To some extent, all 8 of these factors contributed to the severe storm surge that affected the Mississippi coast during the passage of Hurricane Katrina on August 29, 2005. An additional factor was the momentum of water and waves being propelled northward by a storm that had been a Category 5 not long before landfall. In general, the height of Katrina's surge ranged from about 15 feet just east of Pascagoula to 25 to 30 feet in the area around. Surge levels high enough to cause widespread inundation began at times ranging from around 8:00 a.m. along the western part of the Mississippi coast to about 9:00 a.m. along the eastern coast. The surge peaked generally from 10:00 a.m. to 11:00 a.m. and then began to recede around 12:00 noon on the 29th. More specific details on the height and timing of the winds and the storm surge at 100 Holcomb Boulevard in Ocean Springs are presented after the following discussion on the methodology of our research.

METHODOLOGY USED IN THE CREATION OF A WIND AND STORM SURGE TIMELINE FOR 100 HOLCOMB BOULEVARD IN OCEAN SPRINGS

Reconstruction of a timeline of wind and storm surge from Hurricane Katrina at a particular location near the Mississippi coast was made more challenging by the fact that all official wind and storm surge measuring sites along the coast failed well before the height of the storm.

To accomplish this reconstruction, we had to turn to other sources of information. Fundamental to our work was output from the ADCIRC (Advanced Circulation) model, which is a state-of-the-art computer program for solving the equations of motion for a moving fluid on a rotating earth. This model was developed by Dr. Rick Luettich of the University of North Carolina and Dr. Joannes Westerink of the University of Notre Dame. The model has been used and perfected over a period of about 15 years. Applications of the model have ranged from modeling tidal and wind-driven circulations in coastal waters to larval transport studies to studies of dredging feasibility and material disposal to forecasting storm surge and flooding from hurricanes. The ADCIRC model has been used by major government agencies, including the National Oceanic and Atmospheric Administration, the Naval Oceanographic Office, the Naval Research Laboratory, the United States Army Corps of Engineers and has been certified by the Federal Emergency Management Agency for its National Flood Insurance Program. The model has also been used by numerous universities in the United States, including Mississippi State University, Louisiana State University, the University of Florida and the University of South Alabama. Universities in other nations have used the model as well, including schools in Canada, Morocco, Portugal, the United Kingdom, China and Australia. Many parameters are carefully specified and included in the model, including gravity, tides, wind, atmospheric pressure, and land and undersea topography including details of the bays and rivers along the Mississippi coastline. The resolution of the model output is several hundred yards.

AccuWeather contracted with Worldwinds, Inc., based at the Stennis Space Center in Bay St. Louis, Mississippi, to produce a special run of the model for Hurricane Katrina and create output of wind and storm surge timing for numerous specified locations, including 100 Holcomb Boulevard in Ocean Springs. Dr. Pat Fitzpatrick, author of two books on hurricanes and professor at the Stennis Space Center office of Mississippi State University's GeoResources Institute, was instrumental in establishing the correct parameters of the wind and pressure of Hurricane Katrina for this run of the model.

As a reality check on the model results, we conducted separate interviews with dozens of individuals who did not evacuate their homes during Hurricane Katrina and thus were eyewitnesses to the effects of the storm at their location. Eight of these eyewitness reports came from various parts of Ocean Springs, Mississippi. While not sufficiently rigorous to establish an exact timeline, these reports collectively provided valuable information as to the general sequence of events as Katrina moved through.

The output from the ADCIRC model run is in the form of average wind speed and direction and storm surge elevation for the site in question at regular time intervals during the passage of Hurricane Katrina. The output does not include wind gusts or the effects of small-scale wind features such as tornadoes or downbursts.

To determine whether any such localized wind features impacted the site at 105 Holcomb Boulevard, Stephen Wistar of the AccuWeather Forensic Department visited that property and other nearby locations on December 2, 2005, January 6 and 7, 2006, and April 9 and 12, 2006. These visits established that there was clearly visible tornado damage in a swath that included at least a portion of the property at 100 Holcomb Boulevard.

Our next step was to determine when the tornado occurred. For this we turned to data from the Mobile, Alabama National Weather Service Doppler radar, which operated without interruption throughout the day of the storm. As discussed earlier in this report, research has shown that non-eyewall tornadoes within a hurricane are generally found with discrete, small precipitation echoes that show up on Doppler radar with an intensity of at least 50 dBZ, especially when these echoes are part of an organized, persistent rainband. Viewing the continuous record of base reflectivity[3] from the Mobile Doppler, we were able to determine when such echoes moved over Ocean Springs on August 29, 2005.

Additional evidence used in our tornado analysis included:

1) Wind shear data from the Mobile Doppler radar. The software package with the National Weather Service Doppler radar includes several algorithms used for determining the existence and location of wind shear.[4] We used the output from the Mesocyclone and Tornado Vortex Signature algorithms, which mark the location of rotation in the atmosphere at the height of the radar beam. Because the radar beam climbs higher above the ground with greater distance from the radar site (because of the small angle above horizontal of the radar beam as well as the curvature of the earth), the wind shear locations identified by the Doppler are aloft. Thus, while rotation aloft may or may not extend down to the ground, the locations of wind shear identified by the Doppler radar indicate the *potential* for rotation at the ground.
2) A continuous record of wind speed and direction from a high quality private anemometer located in Pascagoula, Mississippi which recorded changes in the storm's wind pattern at that location as a significant rainband moved northward across the Ocean Springs and Pascagoula area on the morning of the 29th. This data source was useful for the entire wind timeline as well.
3) Doppler radar displays of a swath of drier air that moved into the same area in the wake of the same rainband. An influx of drier air aloft into a convective cell is an ingredient for tornado formation.
4) A credible eyewitness report from an individual who evacuated his home, located in the tornado damage swath, early on August 29. His home was subsequently destroyed by the tornado.

[3] The base reflectivity product from the NEXRAD radar system displays the intensity of precipitation echoes closest to the ground using a color code. To obtain the base reflectivity data at a particular time, the radar makes one complete 360-degree sweep at an angle of 0.50 of a degree above horizontal. The resulting color image shows the location and intensity of precipitation on a map. This data is available every 5 to 6 minutes.
[4] Wind shear is a rapid change of wind speed and/or direction over a short vertical or horizontal distance.

Other data sources used in the creation of the timeline of wind and storm surge included official wind and water elevation records along the Mississippi coast, although these were only useful for the early part of the storm as the instrumentation all failed before Katrina's strongest winds and highest water arrived.

DETAILS OF WIND AND STORM SURGE DURING THE PASSAGE OF HURRICANE KATRINA ON AUGUST 29, 2005 AT 100 HOLCOMB BOULEVARD IN OCEAN SPRINGS, MISSISSIPPI

The first showers with Katrina moved across Ocean Springs during the afternoon hours of August 28, 2005. Afternoon winds blew from the east and northeast at an average speed of 15 to 20 MPH with gusts to between 30 and 35 MPH. During the evening hours of the 28th, rain fell most of the time and there were occasional heavy downpours with passing thunderstorms. The wind blew mainly from the northeast, averaging 15 to 25 MPH with gusts to between 35 and 40 MPH.

During the predawn hours of August 29, 2005, rain fell nearly continuously and the wind gusts became more powerful. Between 12:00 Midnight and 2:00 a.m., the wind blew mainly from the northeast at an average speed of 25 to 30 MPH with gusts to between 35 and 45 MPH. The wind direction shifted to east-northeasterly between 2:00 a.m. and 4:00 a.m. and a couple of fairly intense radar echoes (45 to 50 dBZ) moved across the area. The first passed at approximately 2:30 a.m. and the second at 3:35 a.m. These echoes were part of a boundary between winds from the northeast and stronger winds from the east and marked an area of intense convection. Wind gusts to between 55 and 70 MPH occurred in the vicinity of 100 Holcomb Boulevard during this time, causing the first damage to surface features on some buildings along with broken tree limbs.

Between 4:00 a.m. and 6:00 a.m. on the 29th, the wind blew mainly from the east, averaging 30 to 40 MPH with gusts to between 55 and 85 MPH. Through 6:00 a.m., the elevation of the storm surge in nearby Biloxi Bay did not exceed 5 feet.

A significant increase in the storm's ferocity took place between 6:00 a.m. and 6:45 a.m. During this time, a well-defined rainband shifted northward across Ocean Springs and, as it was passing, a tornado struck at least a portion of the property at 100 Holcomb Boulevard. As discussed previously, we visited this location and the surrounding area several times and determined that there was clear evidence of tornado damage. We found this evidence along a path from just east of the intersection of East Beach Drive and Holcomb Boulevard to nearly the western end of East Beach Drive. The most common evidence was snapped and uprooted trees in many varying directions, including in some directions in which the prevailing winds of the storm did not blow. The most extreme tornado damage was visible along the west side of Holcomb Boulevard just north of the intersection with East Beach Drive as well as at a house site at 4 Gulfview Drive, which is located on a peninsula approximately 0.3 of a mile northwest of 100 Holcomb Boulevard. Additionally, a small sports car that had been parked in a garage at 421 East Beach Drive was carried by the wind between 0.1 and 0.2 of a mile to the northwest and set down in woods on a peninsula with vertical scratches only on the right rear portion of the car. It would

not have been able to float to that position due to the woods in which it landed. Using aerial photographs and the location of fallen trees, it is clear that the tornado's path began over the portion of the property at 100 Holcomb Boulevard to the south and southwest of the garage. The tornado traveled a path from southeast to northwest roughly parallel to and on the north side of East Beach Drive.

Base reflectivity data from the Mobile National Weather Service Doppler radar shows that between 6:23 a.m. and 6:43 a.m. on the 29th, cells of intense precipitation (over 50 dBZ) moved rapidly along the rainband from east-southeast to west-northwest across 105 Holcomb Boulevard. A total of four intense convective cells moved over the site during this 20-minute period. We have included a series of radar images from this time period on the CD. Although very strong winds from the hurricane continued for many more hours after 6:43 a.m., these were the last convective cells of this intensity to affect Ocean Springs on August 29.

The wind data from Pascagoula indicates that there was a noticeable overall increase in the wind speeds at that location beginning with the passage of this rainband. The wind data also shows more dramatic variations in the direction of the wind at the time of the rainband passage as compared to other readings during the hour prior. Wind shear from such speed and directional changes in the vicinity of the rainband would aid rotation. The radar data also displays a clear contrast between the heavy rains with the rainband and a parallel band of very light rain just to its south. The availability of this relatively drier air would also aid tornado development.

Additionally, the wind shear data from the Mobile Doppler radar shows a long-lived mesocyclone moving across Ocean Springs from southeast to northwest at approximately 6:40 a.m. All of the above data supports the conclusion that a tornado struck 100 Holcomb Boulevard between 6:23 a.m. and 6:43 a.m. on August 29, 2005.

A key eyewitness report provides confirmation that the tornado occurred after 6:00 a.m. rather than with the convective cells that passed earlier in the morning. This individual remained in his home at 4 Gulfview Drive, in the path of the tornado, until evacuating between 5:00 a.m. and 6:00 a.m. When he left his home, it was intact. Subsequently, the house, located in the same damage swath as 100 Holcomb Boulevard, was completely destroyed by the tornado.

We estimate that wind speeds in the most severe portion of the tornado track reached 150 to 200 MPH. On the portion of the property at 100 Holcomb Boulevard that was affected by the tornado, to the south and southwest of the garage, the highest winds speeds were probably around or somewhat more than 150 MPH. The highest wind speeds from the vicinity of the garage on to the north and east were significantly less with peak gusts most likely in the range of 110 to 125 MPH. The force applied to the upper corners of a wall fully exposed to a wind of 150 MPH is over 50 pounds per square foot. Locally much higher pressures can occur when an exposed wall is struck by airborne debris, which is common at these wind speeds. A more comprehensive discussion of wind pressure on other portions of buildings of various shapes and various exposures is better addressed by an engineer with the appropriate expertise.

After the passage of the rainband, no additional intense precipitation echoes crossed

100 Holcomb Boulevard during the remainder of the storm, although rain continued to fall at a moderate rate. However, severe hurricane-force winds continued. From 6:45 a.m. through 9:00 a.m., the wind blew from the southeast at an average speed of 55 to 75 MPH with gusts to between 90 and 115 MPH, causing additional damage to structures that were hit by the tornado. Structures damaged by the powerful wind gusts before 6:50 a.m. suffered additional damage during this period of very strong winds and the storm surge began to rise at the rate of several feet per hour. At 9:00 a.m., the height of the storm surge had reached approximately 13 feet.

At approximately 9:00 a.m., the wind shifted to southerly and the elevation of the storm surge continued to increase rapidly as water from Biloxi Bay swept inland into Ocean Springs. The wind blew from the south until about 10:30 a.m. and then became more southwesterly during the last part of the morning. Peak gusts still ranged from 90 to 115 MPH through about 10:30 a.m. before easing a little toward the end of the morning. Further wind damage to buildings and trees occurred in the vicinity between 9:00 a.m. and 12:00 noon as the powerful winds blew from a new direction and widespread storm surge damage took place. The storm surge elevation peaked at approximately 11:00 a.m. at a height of about 21 feet and then began to fall about as fast as it had risen.

During the afternoon hours of August 29, the wind continued to blow from the southwest at the site in question and there was a gradual decrease in the strength of the wind. The winds were still gusting to between 75 and 105 MPH during this first hour of the afternoon. By late in the afternoon, the average wind speed had dropped to between 20 and 35 MPH with gusts to between 45 and 60 MPH. The elevation of the storm surge fell from about 17 feet at 12:00 noon to 12 feet at 2:00 p.m. and 5 feet at 6:00 p.m. Rain continued to fall between 12:00 noon and 4:00 p.m., although most of the rain was light after 1:00 p.m. Rainfall with Katrina totaled between 5 and 7 inches in Ocean Springs.

During the evening of the 29th, there was little or no additional rainfall and the wind continued to blow from the southwest, averaging 15 to 20 MPH with gusts to between 25 and 45 MPH. The height of the storm surge continued to slowly drop. The wind and surge diminished further early on August 30 as the storm moved away from the Gulf coast.

The following table displays hourly wind and storm surge information for 100 Holcomb Boulevard in Ocean Springs from 12:00 midnight through 6:00 p.m. on August 29, 2005. The short-duration extreme winds with the tornado are not included in this table. A graphical representation of this data is included on the CD accompanying this report.

TIME (CDT)	DIRECTION FROM WHICH THE WIND WAS BLOWING	AVERAGE WIND SPEED (MPH)	PEAK WIND GUSTS (MPH)	HEIGHT OF STORM SURGE (FEET)
12:00 midnight	Northeast	20	35	2
1:00 a.m.	Northeast	25	40	2

2:00 a.m.	Northeast	30	45	3
3:00 a.m.	East-northeast	35	60	3
4:00 a.m.	East-northeast	35	70	3
5:00 a.m.	East	45	75	4
6:00 a.m.	East	55	100	5
7:00 a.m.	Southeast	70	110	7
8:00 a.m.	Southeast	70	115	9
9:00 a.m.	South-southeast	70	110	13
10:00 a.m.	South	65	105	17
11:00 a.m.	South-southwest	65	100	21
12:00 noon	Southwest	55	95	17
1:00 p.m.	Southwest	45	85	14
2:00 p.m.	Southwest	40	80	12
3:00 p.m.	Southwest	45	85	10
4:00 p.m.	Southwest	40	80	8
5:00 p.m.	Southwest	35	60	6
6:00 p.m.	Southwest	25	50	5

NEW OFFICIAL FUJITA SCALE

As a final note, we wish to point out that the Fujita scale used to determine tornado intensity is being revised and a new official version of the scale will be used by the National Weather Service beginning in 2007. One of the most significant changes being made is to adjust downward the strength of wind required to significantly damage or destroy a home. This change is based on years of research and experience in the field. The following table lists the range of wind speed expected to cause varying degrees of damage to a residence. A range is used to account for variations in the quality of construction, with the lowest speed for each category applicable to poor construction and the highest speed relevant for high quality construction. We should point out that this scale is designed for tornado damage, which usually takes place in a matter of seconds. The relentless pounding by hurricane winds over a period of hours would further lower the wind threshold required to cause these levels of damage.

DAMAGE DESCRIPTION	POOR CONSTUCTION (MPH)	AVERAGE CONSTRUCTION (MPH)	BEST QUALITY CONSTRUCTION (MPH)
Threshold of visible damage	53	65	80
Loss of less than 20% of roof covering, gutters, awnings; loss of siding	63	79	97
Broken glass in	79	96	114

door and windows			
Uplift of roof deck and loss of more than 20% of roof covering; chimney collapse; garage doors collapse inward; failure of porch or carport	81	97	116
Entire house shifts off foundation	103	121	141
Large sections of roof structure removed; most walls still standing	104	122	142
Top floor exterior walls collapsed	113	132	153
Most interior walls of top story collapsed	128	148	173
Most walls collapsed in bottom floor, except small interior rooms	127	152	178
Total destruction of entire building	142	170	198

CONCLUSION

Hurricane Katrina brought devastation to the entire Mississippi coastline on August 29, 2005. At 100 Holcomb Boulevard, Ocean Springs, Jackson County, Mississippi, the wind gradually increased during the late evening of August 28 and the first six hours of the 29th, accompanied by periods of very heavy rain. Then, between 6:23 a.m. and 6:43 a.m., four intense convective cells moved from east-southeast to west-northwest across 100 Holcomb Boulevard, bringing torrential downpours and strong wind gusts. A fast-moving tornado caused by one of the cells swept across the portion of the property to the south and southwest of the garage during the 20-minute period, producing brief wind gusts to around or a little more than 150 MPH. The tornado caused severe damage to homes and trees in the neighborhood and carried a nearby homeowner's small car between 0.1 and 0.2 of a mile to the northwest. At this time of the morning, no storm surge had yet affected the property.

After the tornado passage, the storm continued to rage. Wind damage continued to occur with gusts to between 90 and 115 MPH for the next four hours or so before easing a little late in the morning. The elevation of the storm surge increased at a rate of 3 to 4 feet per hour from

7:00 a.m. on until reaching a damaging peak height of approximately 21 feet at about 11:00 a.m. Both the wind speed and the storm surge began to drop during the last hour of the morning, with this trend continuing throughout the afternoon. Little or no additional damage occurred after mid-afternoon.

Our research clearly shows that the most severe wind gusts struck 100 Holcomb Boulevard well before the arrival of the damaging portion of the storm surge. The most damaging winds occurred with the tornado prior to 7:00 a.m. on August 29 while the rapid rise in the elevation of the storm surge water began after this time and the surge did not peak until approximately 11:00 a.m.

The conclusions in this report are based on currently available information. We reserve the right to modify this report in the future if new information becomes available that would materially change our findings.

The information in this report has been determined from the best sources of weather information available to us at this time and is the result of interpretation by our staff of professional meteorologists and represents our opinions to a reasonable degree of scientific certainty.

We trust that this information is useful to you. If you should have any additional questions or need additional information, please do not hesitate to contact us.

Sincerely,

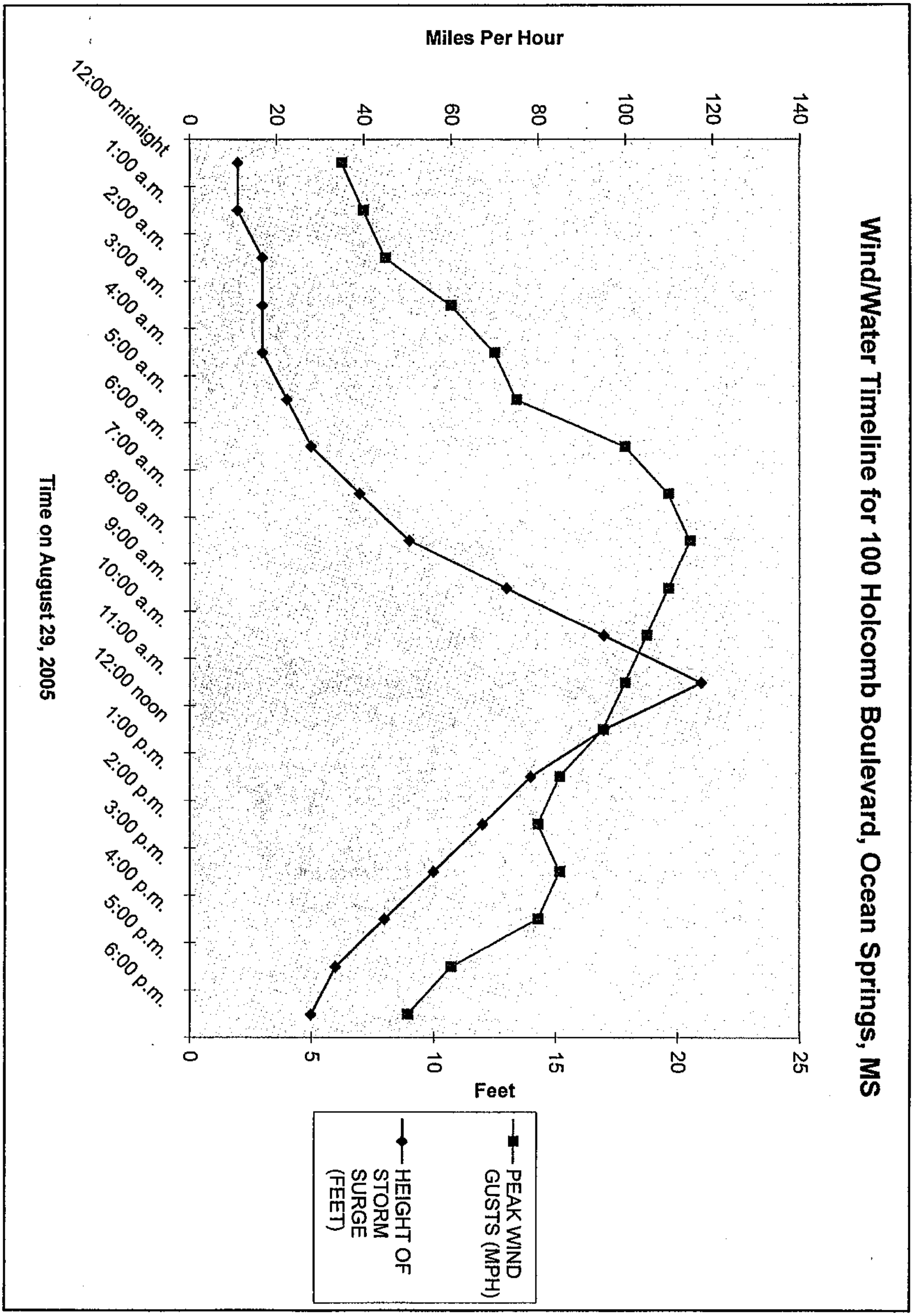
Joseph P. Sobel

Joseph P. Sobel, Ph.D.
Director of Forensic Services

Stephen M. Wistar

Stephen M. Wistar
Certified Consulting Meteorologist

JPS/SMW:amb


Wind/Water Timeline for 100 Holcomb Boulevard, Ocean Springs, MS
Miles Per Hour
0
20
40
60
80
100
120
140
Feet
0
5
10
15
20
25
12:00 midnight
1:00 a.m.
2:00 a.m.
3:00 a.m.
4:00 a.m.
5:00 a.m.
6:00 a.m.
7:00 a.m.
8:00 a.m.
9:00 a.m.
10:00 a.m.
11:00 a.m.
12:00 noon
1:00 p.m.
2:00 p.m.
3:00 p.m.
4:00 p.m.
5:00 p.m.
6:00 p.m.
Time on August 29, 2005
PEAK WIND GUSTS (MPH)
HEIGHT OF STORM SURGE (FEET)

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March 8, 2006

Mr. Dan Magruder
12100 Intraplex Drive
Gulfport, MS 39503

RE: Katrina
AccuWeather File Number: 100548

Dear Mr. Magruder:

As you requested, we have investigated the weather conditions at 421 East Beach Drive, Ocean Springs, Jackson County, Mississippi during Hurricane Katrina on August 29, 2005, with particular attention to a timeline of wind and storm surge along with other related issues. The results of our investigation are presented in the following paragraphs and tables. Photographs, color Doppler radar images and a wind/surge timeline graph are included on the CD that accompanies this report.

SOURCES OF INFORMATION

The following sources of data and information were used in the preparation of this report:

1) *Tropical Cyclone Report - Hurricane Katrina*, published by the National Hurricane Center on December 20, 2005.
2) *Hurricane Katrina – A Climatological Perspective*, Preliminary Report; Technical Report 2005-01, published by the National Climatic Data Center in October 2005.
3) *Hurricane Katrina and Its Aftermath*, Appendix A to an as yet untitled building code report in preparation by civil engineering faculty at Mississippi State University; Appendix A prepared by Pat Fitzpatrick and Yee Lau in January 2006.
4) *A WSR-88D Assessment of Tropical Cyclone Outer Rainband Tornadoes*, by Scott M. Spratt, David W. Sharp, Pat Welsh, Al Sandrik, Frank Alsheimer and Charlie Paxton, all of the National Weather Service; published in Weather and Forecasting, a journal of the American Meteorological Society, in 1997.
5) Surface wind analyses of Hurricane Katrina for selected times on August 29, 2005, produced by the Hurricane Research Division of the National Oceanic and Atmospheric Administration.
6) Hourly surface weather observations for August 28 and 29, 2005 from airports in Bay St. Louis, Biloxi and Pascagoula, Mississippi, taken by the National Weather Service and the Federal Aviation Administration.
7) Wind data from observation sites in Bay St. Louis and Pascagoula, Mississippi, operated by universities and private sources, including Texas Tech University, the University of Florida and Florida International University.

EXHIBIT 7
Witness
Date
Reporter: Danielle Freeze

8) Storm surge data for August 29, 2005 from observations sites in Waveland and Horn Island, both in Mississippi and Dauphin Island, Alabama, taken by the National Ocean Service.
9) Initial Hurricane Katrina Landfall Wind Speed Estimates prepared for the Federal Emergency Management Agency by Applied Research Associates, Inc.
10) Post-Tropical Cyclone Report for Hurricane Katrina prepared by the National Weather Service Forecast Office in New Orleans, Louisiana.
11) Hurricane Katrina Tornado Warnings and Eye-Wall Warnings issued by the National Weather Service Forecast Office in New Orleans, Louisiana on August 29, 2005.
12) Hurricane Katrina Cumulative Rainfall Stage III Multi-Sensor Precipitation Estimate issued by the National Weather Service Southern Region Headquarters.
13) Storm reports for August 29, 2005, issued by the National Weather Service Storm Prediction Center.
14) Base reflectivity data, mesocyclone and tornado vortex signature data for selected times on August 29, 2005 from the National Weather Service Doppler radar in Mobile, Alabama.
15) Mississippi Hurricane Katrina Surge Inundation and elevation maps issued in November 2005 by the Federal Emergency Management Agency.
16) Aerial photographs of Mississippi coast damage areas taken by the National Oceanic and Atmospheric Administration within a few days after August 29, 2005.
17) Personal visits to 421 East Beach Drive, Ocean Springs, Mississippi and nearby locations by Stephen Wistar, CCM on December 2, 2005 and January 6 and 7, 2006.
18) First-hand reports from dozens of individuals along the Mississippi coast who did not evacuate and thus were eyewitnesses to Hurricane Katrina, including eight in Ocean Springs.
19) Wind and surge data for Ocean Springs from the Advanced Circulation (ADCIRC) model, made available by WorldWinds, Inc. in March 2006.
20) Personal communication with Ted L. Biddy, P.E., P.L.S.
21) Personal communication with Chris J. Peterson, Ph.D., Associate Professor of Plant Biology at the University of Georgia.
22) Personal communication with Gregory Forbes, Ph.D., severe weather expert at the Weather Channel
23) Report on the Fujita Scale Enhancement Project, submitted to the National Weather Service by the Wind Science and Engineering Center of Texas Tech University in June 2004.

OVERVIEW OF HURRICANE KATRINA

Hurricane Katrina ranks as one of the worst natural disasters in the history of the United States. The death toll from the storm is the highest in the country since 1928 and the total damage cost is far above that of Hurricane Andrew in 1992, which had been the costliest natural disaster in the nation's history.

Katrina began its life as Tropical Depression Twelve on August 23, 2005 over the southeastern Bahamas. The system strengthened into Tropical Storm Katrina the next day as it moved

through the central Bahamas. The storm reached minimal Category 1 strength on the Saffir-Simpson hurricane scale on August 25, 2005 just before making landfall near North Miami Beach, Florida. During that night, Katrina weakened only slightly while moving west-southwestward across the southern Florida Peninsula and caused substantial damage, flooding and eleven deaths. The following table shows the Saffir-Simpson hurricane scale.

STORM CATEGORY	PRESSURE (millibars)	PRESSURE (inches)	SUSTAINED WINDS (mph)
1	980 to 1000	28.93 to 29.53	74 to 95
2	965 to 979	28.49 to 28.92	96 to 110
3	945 to 964	27.90 to 28.48	111 to 130
4	920 to 944	27.17 to 27.89	131 to 155
5	Less than 920	Less than 27.17	156 and up

Once the storm moved back over water in the southeastern Gulf of Mexico, atmospheric and oceanic conditions were very conducive to strengthening and Katrina attained major hurricane status, Category 3, on the afternoon of August 26, 2005. The strengthening continued on August 27 as the storm moved westward and was accompanied by a dramatic expansion outward of hurricane-force winds. Katrina nearly doubled in width on the 27th, resulting in a large hurricane of a size most commonly seen in western Pacific Ocean typhoons.

Hurricane Katrina turned toward the northwest into the central Gulf of Mexico on August 28, 2005 and, after a period of explosive deepening over the warmest water in the Gulf, reached its maximum Category 5 strength that morning while the center of the storm was located nearly 200 miles southeast of the mouth of the Mississippi River. Peak sustained winds at that time were estimated at 172 MPH. The barometric pressure in the eye fell to its minimum of 902 millibars (26.64 inches) on the afternoon of the 28th. At the time, this was the 4th lowest pressure on record for an Atlantic basin hurricane. However, Hurricanes Rita and Wilma had even lower barometric pressures during their lifetimes and pushed Katrina into 6th place by the end of the 2005 hurricane season.

Early on August 29, 2005, Hurricane Katrina turned northward toward the Mississippi River Delta and then made landfall near Buras, Louisiana at 6:10 a.m.[1] At 9:45 a.m., the eye of Katrina was making its second Gulf coast, and final overall, landfall near the mouth of the Pearl River on the Louisiana-Mississippi border.

There was a significant change in the structure of Katrina from August 28 to August 29 as it moved steadily northward toward the Gulf coast. On Sunday the 28th, when the storm was at its peak strength over the warmest waters of the Gulf of Mexico, the strongest winds were concentrated near the center As the storm pulled in some dry air from its western side while at the same time encountering lower oceanic heat content close to the coast, the inner eyewall

[1] This and all other time references in this report are expressed in Central Daylight Time (CDT).

weakened before landfall on the morning of Monday the 29th while at the same time there was a strengthening of winds 30 to 50 miles east of the center, especially above the surface. Thus, there was a spreading out of the winds and the storm remained unusually large in areal extent. Since the highest sustained winds of a hurricane, usually found in or near the eyewall, determine the official strength in terms of its category, Katrina was officially downgraded before landfall. There is currently some controversy regarding the strength of Katrina at landfall. The official final report from the National Hurricane Center lists it as a Category 3 at that time with maximum sustained winds of about 125 MPH at the first Gulf landfall near Buras, Louisiana and 120 MPH at the second Gulf landfall near the Louisiana/Mississippi border. The pressure at the first landfall was 920 millibars (27.17 inches) and the pressure at the final landfall was 928 millibars (27.40 inches). Thus, even though peak sustained wind speeds at landfall were at Category 3 intensity, the barometric pressure of the storm remained at strong Category 4 intensity.

Despite the overall weakening of Hurricane Katrina prior to landfall, it was still a major and very large hurricane when it came onshore. Bands of intense convection[2], both in the eyewall and in rain bands outside the eye, brought strong winds aloft down to the ground in fierce gusts, triggering scattered tornadoes and downbursts. Areas of severe damage resulted from these localized bursts of wind, many of which occurred along the Mississippi coast prior to the final landfall.

Hurricane Katrina also brought a severe storm surge to the Gulf coast from eastern Louisiana to western Alabama, including the entire Mississippi coast. In Mississippi, the surge rose rapidly one to two hours before Katrina's final landfall at the mouth of the Pearl River and peaked within an hour or so after that landfall, causing widespread damage in coastal cities and towns. The surge was highest along the western part of the Mississippi coast where the eye of the storm made landfall.

Heavy rainfall accompanied Hurricane Katrina along the entire Mississippi coast, with estimated amounts ranging from 5 to 10 inches.

Inevitably, comparisons have been drawn between Hurricane Katrina and Hurricane Camille, which made landfall in nearly the same location in August 1969. Camille was more intense than Katrina at the time of landfall but covered a much smaller area. At the time of landfall, the eye of Camille was 11 miles across while the eye of Katrina was approximately 35 miles wide. Thus, the powerful winds in and near the eyewall affected a much larger area with Katrina than with Camille. Hurricane force winds with Katrina extended 120 miles out from the storm's center, twice as far as Camille's winds. Katrina was moving slower than Camille when coming onshore, causing a longer period of wind exposure and increasing the height of the storm surge.

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[2] Convection in the atmosphere, usually manifested in the form of thunderstorms, contains strong rising and sinking currents of air. Convection can result in strong wind gusts at the ground as higher velocity air aloft is directed downward by sinking currents of air.

In the following sections of this report, we discuss hurricane wind and storm surge characteristics in more detail, including details specific to Katrina We present our methodology for determining the timing of wind and storm surge details for a given location. Then, we present a timeline of the wind direction and speed along with the height of the storm surge for 421 East Beach Drive in Ocean Springs during Hurricane Katrina A summary and conclusions follow.

WIND CHARACTERISTICS OF HURRICANES

Hurricane intensity is defined by sustained winds and not the strength of short-lived wind gusts. Officially, for Atlantic basin hurricanes, sustained winds represent the average speed over a one-minute period at a height of 10 meters (33 feet) above the surface. The intensity of a storm is determined by the strongest sustained winds that can be found in any portion of the circulation of the storm, with the speed being adjusted to the 33-foot height by a mathematical relationship that describes how wind speed normally varies with changing height above the surface.

In reality, the speed of the wind at a given location in a hurricane is constantly changing due to a variety of factors, including turbulence, convective downdrafts and frictional effects over land where there is more disruption of the airflow than over water. These effects cause frequent wind gusts, which are sudden, brief increases in speed for a period of several seconds. With all other factors being equal, sustained wind speeds will be lower over land than water, but the percentage increase in wind speeds during gusts will be higher over land due to turbulent eddies. Research has shown that, over water, the speed of wind gusts will typically be about 25 percent higher than sustained wind speeds. Over flat land with no obstructions, the strength of gusts will average a 35 percent increase over sustained wind speeds In the lowest part of the atmosphere over forested and urban areas, the sustained winds are slowed substantially compared to over water, but the gust factor increases to 65 percent as the still strong winds aloft penetrate down to the ground at times. In a hurricane, these wind gusts are responsible for a significant portion of the wind-induced damage to buildings and trees.

Localized even stronger wind impacts can occur in hurricanes, primarily where convection is concentrated in the eyewall and in rain bands outside the eye. In these locations, downbursts or tornadoes can take place over relatively small areas, usually in swaths that are no more than a mile or two long and less than a mile wide. A downburst results from a strong downdraft that hits the ground and then spreads out horizontally. Enhanced surface winds in a hurricane downdraft blow generally in a straight or slightly curving path.

Tornadoes occur within most major land-falling hurricanes. Research has revealed the following circumstances are most highly correlated with tornadoes:

1) Tornadoes are most common in the right front quadrant of the storm at landfall.
2) Tornadoes are most common near the hurricane core within 60 miles of the eye on the day of landfall.
3) Large hurricanes produce more tornadoes than small hurricanes.
4) More intense hurricanes produce more tornadoes than less intense storms.

5) The optimal forward speed of a hurricane for tornado production is between 8 and 33 MPH.
6) Tornadoes are far more common with hurricanes making landfall from the Gulf of Mexico than with those making landfall from the Atlantic Ocean.
7) Tornadoes are affiliated with discrete, small but intense precipitation echoes on radar, especially when these echoes are part of an organized, persistent rainband. On National Weather Service Doppler radar (NEXRAD) images, the intensity of the color-coded echoes is measured in dBZ's (decibels of "Z", which is a reflectivity factor). Research has shown that the echoes must have a minimum intensity of 50 dBZ to be considered as a possible tornado-producer.
8) Many of the tornadoes with land-falling hurricanes occur very near the coast due to impacts on the airflow as it encounters increased and varied frictional effects when blowing from water to land.
9) There are also tornado-like vortices that are often found in the eyewall of the hurricane itself. The eyewall of Katrina remained to the west of Ocean Springs.

OBSERVATIONS OF TORNADO AND DOWNBURST DAMAGE IN COASTAL MISSISSIPPI WITH HURRICANE KATRINA

All nine of these characteristics were present along the Mississippi coast with Hurricane Katrina. Indeed, during our travels along the entire length of the coast, we witnessed numerous concentrated damage swaths due to wind. Some of these swaths showed evidence of straight-line wind damage and others showed evidence of tornado damage. There is no official record of tornadoes or downbursts in the three Mississippi coastal counties with Katrina. Normally, the National Weather Service will conduct field surveys following a hurricane to document tornado or downburst paths. However, this was not done following Hurricane Katrina, probably due to problems the New Orleans office of the National Weather Service was having after being forced to relocate their operation to Lake Charles, Louisiana for a lengthy period following the storm. We believe that in actuality there were dozens, if not over one hundred separate downbursts or tornadoes in southern Mississippi on the morning of August 29, 2005 when Hurricane Katrina made landfall. Additionally, because of the large size of the storm, locations throughout the Mississippi coast were exposed to hurricane-force wind gusts for many hours.

STORM SURGE WITH HURRICANES

All land-falling hurricanes have a storm surge that is caused by the force of the wind driving water toward the coast. The surge from a hurricane is very different from a tsunami in that the surge arrives as a steadily rising level of water rather than as a large wave. There is always some wave action along the immediate coast with the storm surge, but as the surge moves inland the waves are damped out by obstacles such as trees and buildings. Both the surge and accompanying waves can cause major damage. The following factors play a role in the elevation attained by the storm surge with a hurricane:

1) The stronger the winds in a hurricane, the higher the level of the storm surge.
2) A hurricane that covers a large area will in general have a higher storm surge than a storm with a small areal extent.

3) The lower the atmospheric pressure (weight of the atmosphere) in the storm, the more the water will expand upward. The water level rises 3.9 inches for every 10-millibar drop in the hurricane's central pressure.
4) A shallow offshore shelf will force a storm surge to pile up on itself and attain a higher level than if the shelf drops off rapidly near the coast.
5) Larger waves arriving at the coastline will propel the surge further inland than smaller waves.
6) The angle at which the storm approaches the coast influences the height of the surge. The surge is highest when a storm makes landfall perpendicular to the coast.
7) The surge is highest on the right side of the place of landfall where the winds are blowing onshore.
8) The background tides affect the surges height. A surge arriving at high tide will have a higher elevation than at low tide.

STORM SURGE WITH HURRICANE KATRINA

To some extent, all 8 of these factors contributed to the severe storm surge that affected the Mississippi coast during the passage of Hurricane Katrina on August 29, 2005. An additional factor was the momentum of water and waves being propelled northward by a storm that had been a Category 5 not long before landfall. In general, the height of Katrina's surge ranged from about 15 feet just east of Pascagoula to 25 to 30 feet in the area around St. Louis Bay. Surge levels high enough to cause widespread inundation began at times ranging from around 8:00 a.m. along the western part of the Mississippi coast to about 9:00 a.m. along the eastern coast. The surge peaked generally from 10:00 a.m. to 11:00 a.m. and then began to recede around 12:00 noon on the 29th. More specific details on the height and timing of the winds and the storm surge at 421 East Beach Drive in Ocean Springs are presented after the following discussion on the methodology of our research.

METHODOLOGY USED IN THE CREATION OF A WIND AND STORM SURGE TIMELINE FOR 421 EAST BEACH DRIVE IN OCEAN SPRINGS

Reconstruction of a timeline of wind and storm surge from Hurricane Katrina at a particular location near the Mississippi coast was made more challenging by the fact that all official wind and storm surge measuring sites along the coast failed well before the height of the storm.

To accomplish this reconstruction, we had to turn to other sources of information. We used output from the ADCIRC (Advanced Circulation) model, which is a state-of-the-art computer program for solving the equations of motion for a moving fluid on a rotating earth. This model was developed by Dr. Rick Luettich of the University of North Carolina and Dr. Joannes Westerink of the University of Notre Dame. The model has been used and perfected over a period of about 15 years. Applications of the model have ranged from modeling tidal and wind-driven circulations in coastal waters to larval transport studies to studies of dredging feasibility and material disposal to forecasting storm surge and flooding from hurricanes. The ADCIRC model has been used by major government agencies, including the National Oceanic and Atmospheric Administration, the Naval Oceanographic Office, the Naval Research Laboratory,

the United States Army Corps of Engineers and has been certified by the Federal Emergency Management Agency for its National Flood Insurance Program. The model has also been used by numerous universities in the United States, including Mississippi State University, Louisiana State University, the University of Florida and the University of South Alabama. Universities in other nations have used the model as well, including schools in Canada, Morocco, Portugal, the United Kingdom, China and Australia. Many parameters are carefully specified and included in the model, including gravity, tides, wind, atmospheric pressure, and land and undersea topography including details of the bays and rivers along the Mississippi coastline. The resolution of the model output is several hundred yards.

AccuWeather contracted with Worldwinds, Inc., based at the Stennis Space Center in Bay St. Louis, Mississippi, to produce a special run of the model for Hurricane Katrina and create output of wind and storm surge timing for numerous specified locations, including 421 East Beach Drive in Ocean Springs. Dr. Pat Fitzpatrick, author of two books on hurricanes and professor at the Stennis Space Center office of Mississippi State University's GeoResources Institute, was instrumental in establishing the correct parameters of the wind and pressure of Hurricane Katrina for this run of the model.

As a reality check on the model results, we conducted separate interviews with dozens of individuals who did not evacuate their homes during Hurricane Katrina and thus were eyewitnesses to the effects of the storm at their location. Eight of these eyewitness reports came from various parts of Ocean Springs, Mississippi. While not sufficiently rigorous to establish an exact timeline, these reports collectively provided valuable information as to the general sequence of events as Katrina moved through.

The output from the ADCIRC model run is in the form of average wind speed and direction and storm surge elevation for the site in question at regular time intervals during the passage of Hurricane Katrina. The output does not include wind gusts or the effects of small-scale wind features such as tornadoes or downbursts.

To determine whether any such localized wind features impacted the site at 421 East Beach Drive, Stephen Wistar of the AccuWeather Forensic Department visited that property and other nearby locations on December 2, 2005 and January 6 and 7, 2006. These visits established that there was clearly visible tornado damage in a swath that included the property at 421 Beach Drive.

Our next step was to determine when the tornado occurred. For this we turned to data from the Mobile, Alabama National Weather Service Doppler radar, which operated without interruption throughout the day of the storm. As discussed earlier in this report, research has shown that non-eyewall tornadoes within a hurricane are generally found with discrete, small precipitation echoes that show up on Doppler radar with an intensity of at least 50 dBZ, especially when these echoes are part of an organized, persistent rainband. Viewing the continuous record of base

reflectivity[3] from the Mobile Doppler, we were able to determine when such echoes moved over Ocean Springs on August 29, 2005.

Additional evidence used in our tornado analysis included:

1) Wind shear data from the Mobile Doppler radar. The software package with the National Weather Service Doppler radar includes several algorithms used for determining the existence and location of wind shear.[4] We used the output from the Mesocyclone and Tornado Vortex Signature algorithms, which mark the location of rotation in the atmosphere at the height of the radar beam. Because the radar beam climbs higher above the ground with greater distance from the radar site (because of the small angle above horizontal of the radar beam as well as the curvature of the earth), the wind shear locations identified by the Doppler are aloft. Thus, while rotation aloft may or may not extend down to the ground, the locations of wind shear identified by the Doppler radar indicate the *potential* for rotation at the ground.
2) A continuous record of wind speed and direction from a high quality private anemometer located in Pascagoula, Mississippi which recorded changes in the storm's wind pattern at that location as a significant rainband moved northward across the Ocean Springs and Pascagoula area on the morning of the 29th. This data source was useful for the entire wind timeline as well.
3) Doppler radar displays of a swath of drier air that moved into the same area in the wake of the same rainband. An influx of drier air aloft into a convective cell is an ingredient for tornado formation.
4) A credible eyewitness report from an individual who evacuated his home, located in the tornado damage swath, early on August 29. His home was subsequently destroyed by the tornado.

Other data sources used in the creation of the timeline of wind and storm surge included official wind and water elevation records along the Mississippi coast, although these were only useful for the early part of the storm as the instrumentation all failed before Katrina's strongest winds and highest water arrived.

DETAILS OF WIND AND STORM SURGE DURING THE PASSAGE OF HURRICANE KATRINA AT 421 EAST BEACH DRIVE IN OCEAN SPRINGS, MISSISSIPPI

The first showers with Katrina moved across Ocean Springs during the afternoon hours of August 28, 2005. Afternoon winds blew from the east and northeast at an average speed of 15 to 25 MPH with gusts to between 30 and 40 MPH. During the evening hours of the 28th, rain fell most of the time and there were occasional heavy downpours with passing thunderstorms. The

[3] The base reflectivity product from the NEXRAD radar system displays the intensity of precipitation echoes closest to the ground using a color code To obtain the base reflectivity data at a particular time, the radar makes one complete 360-degree sweep at an angle of 0.50 of a degree above horizontal. The resulting color image shows the location and intensity of precipitation on a map This data is available every 5 to 6 minutes

[4] Wind shear is a rapid change of wind speed and/or direction over a short vertical or horizontal distance.

wind blew mainly from the northeast, averaging 15 to 30 MPH with gusts to between 35 and 45 MPH.

During the predawn hours of August 29, 2005, rain fell nearly continuously and the wind gusts became more powerful Between 12:00 Midnight and 2:00 a.m., the wind blew mainly from the northeast at an average speed of 25 to 35 MPH with gusts to between 40 and 50 MPH. The wind direction shifted to east-northeasterly between 2:00 a.m. and 4:00 a.m. and a couple of fairly intense radar echoes (45 to 50 dBZ) moved across the area. The first passed at approximately 2:30 a.m. and the second at 3:35 a.m. These echoes were part of a boundary between winds from the northeast and stronger winds from the east and marked an area of intense convection. Wind gusts to between 60 and 75 MPH occurred in the vicinity of 421 East Beach Drive during this time, causing the first damage to surface features on some buildings along with broken tree limbs.

Between 4:00 a.m. and 6:00 a.m. on the 29th, the wind blew mainly from the east, averaging 35 to 45 MPH with gusts to between 60 and 90 MPH. Through 6:00 a.m., the elevation of the storm surge in Biloxi Bay across the street from the site in question did not exceed 5 feet.

A significant increase in the storm's ferocity took place between 6:00 a.m. and 6:45 a.m. During this time, a well-defined rainband shifted northward across Ocean Springs and, as it was passing, a tornado struck 421 East Beach Drive. As discussed previously, we visited this location and the surrounding area and determined that there was clear evidence of tornado damage at the site. The most common evidence was snapped and uprooted trees in many varying directions, including in some directions in which the prevailing winds of the storm did not blow. We found this evidence along a path from the eastern end to nearly the western end of East Beach Drive. The most extreme tornado damage was visible along Holcomb Boulevard just north of the intersection with East Beach Drive as well as at a house site at 4 Gulfview Drive, which is located on a peninsula slightly more than 0 1 of a mile north of East Beach Drive. Additionally, a small sports car that had been parked in the house at 421 East Beach Drive was carried by the wind between 0.1 and 0.2 of a mile to the northwest and set down in woods on a peninsula with vertical scratches only on the right rear portion of the car. It would not have been able to float to that position due to the woods in which it landed. The tornado traveled a path from east-southeast to west-northwest roughly parallel to and on the north side of East Beach Drive. Two photographs from our visit to the area are included on the accompanying CD. One shows a tree next to the house at 421 East Beach Drive that fell toward the south, a direction of fall that could have only happened in the rotating winds of a tornado, since strong winds never blew from the north during the hurricane. Another photograph shows the final resting place of the car that was carried into the woods.

Base reflectivity data from the Mobile National Weather Service Doppler radar shows that between 6:23 a.m. and 6:43 a.m. on the 29th, cells of intense precipitation (over 50 dBZ) moved rapidly along the rainband from east-southeast to west-northwest across 421 East Beach Drive. A total of four intense convective cells moved over the site during this 20-minute period. We have included a series of radar images from this time period on the CD. Although very strong

winds from the hurricane continued for many more hours after 6:43 a.m., these were the last convective cells of this intensity to affect Ocean Springs on August 29.

The wind data from Pascagoula indicates that there was a noticeable overall increase in the wind speeds at that location beginning with the passage of this rainband. The wind data also shows more dramatic variations in the direction of the wind at the time of the rainband passage as compared to other readings during the hour prior. Wind shear from such speed and directional changes in the vicinity of the rainband would aid rotation. The radar data also displays a clear contrast between the heavy rains with the rainband and a parallel band of very light rain just to its south. The availability of this relatively drier air would also aid tornado development.

Additionally, the wind shear data from the Mobile Doppler radar shows a long-lived mesocyclone moving across Ocean Springs from southeast to northwest at approximately 6:40 a.m. All of the above data supports the conclusion that a tornado struck 421 East Beach Drive between 6:23 a.m. and 6:43 a.m. on August 29, 2005.

A key eyewitness report provides confirmation that the tornado occurred after 6:00 a.m. rather than with the convective cells that passed earlier in the morning. This individual remained in his home at 4 Gulfview Drive, in the path of the tornado, until evacuating between 5:00 a.m. and 6:00 a.m. When he left his home, it was intact Subsequently, the house, located approximately 500 feet north of the 421 East Beach Drive property, was completely destroyed by the tornado.

We estimate that wind speeds in the tornado reached 150 to 200 MPH. The force applied to the upper corners of a wall fully exposed to a wind of 150 MPH is over 50 pounds per square foot. With a wind of 200 MPH, the force on this portion of a fully exposed wall would be well over 80 pounds per square foot. Locally much higher pressures can occur when an exposed wall is struck by airborne debris, which is common at these wind speeds. A more comprehensive discussion of wind pressure on other portions of buildings of various shapes and various exposures is better addressed by an engineer with the appropriate expertise.

After the passage of the rainband, no additional intense precipitation echoes crossed 421 East Beach Drive during the remainder of the storm, although rain continued to fall at a moderate rate. However, severe hurricane-force winds continued. From 6:45 a.m. through 9:00 a.m., the wind blew from the southeast at an average speed of 60 to 80 MPH with gusts to between 95 and 125 MPH, causing additional damage to structures that were hit by the tornado. Structures damaged by the powerful wind gusts before 6:50 a.m. suffered additional damage during this period of very strong winds and the storm surge began to rise at the rate of several feet per hour. At 9:00 a.m., the height of the storm surge had reached approximately 14 feet.

At approximately 9:00 a.m., the wind shifted to southerly and the elevation of the storm surge continued to increase rapidly as water from Biloxi Bay swept inland into Ocean Springs. The wind blew from the south until about 10:30 a.m. and then became more southwesterly during the last part of the morning. With an open exposure to the south and southwest, the property at 421 East Beach Drive continued to be subjected to very strong winds during this time. Peak gusts still ranged from 95 to 125 MPH through about 10:30 a.m. before easing a little toward the end

of the morning. Further wind damage to buildings and trees occurred in the vicinity between 9:00 a.m. and 12:00 noon as the powerful winds blew from a new direction and widespread storm surge damage took place. The storm surge elevation peaked at approximately 11:00 a.m. at a height of about 22 feet and then began to fall about as fast as it had risen

During the afternoon hours of August 29, the wind continued to blow from the southwest at the site in question and there was a gradual decrease in the strength of the wind. The winds were still gusting to between 80 and 110 MPH during this first hour of the afternoon. By late in the afternoon, the average wind speed had dropped to between 20 and 40 MPH with gusts to between 50 and 65 MPH. The elevation of the storm surge fell from about 18 feet at 12:00 noon to 13 feet at 2:00 p.m. and to 5 feet at 6:00 p.m. Rain continued to fall between 12:00 noon and 4:00 p.m., although most of the rain was light after 1:00 p.m. Rainfall with Katrina totaled between 5 and 7 inches in Ocean Springs

During the evening of the 29th, there was little or no additional rainfall and the wind continued to blow from the southwest, averaging 15 to 25 MPH with gusts to between 30 and 50 MPH. The height of the storm surge continued to slowly drop. The wind and surge diminished further early on August 30 as the storm moved away from the Gulf coast.

The following table displays hourly wind and storm surge information for 421 East Beach Drive in Ocean Springs from 12:00 midnight through 6:00 p.m. on August 29, 2005. The short-duration extreme winds with the tornado are not included in this table. A graphical representation of this data is included on the CD accompanying this report.

TIME (CDT)	DIRECTION FROM WHICH THE WIND WAS BLOWING	AVERAGE WIND SPEED (MPH)	PEAK WIND GUSTS (MPH)	HEIGHT OF STORM SURGE (FEET)
12:00 midnight	Northeast	25	40	2
1:00 a.m.	Northeast	30	45	2
2:00 a.m.	Northeast	35	50	3
3:00 a.m.	East-northeast	40	65	3
4:00 a.m.	East-northeast	40	75	3
5:00 a.m.	East	50	80	4
6:00 a.m.	East	60	105	5
7:00 a.m.	Southeast	75	115	7
8:00 a.m.	Southeast	75	125	10
9:00 a.m.	South-southeast	75	125	14
10:00 a.m.	South	70	115	18
11:00 a.m.	South-southwest	70	105	22
12:00 noon	Southwest	60	100	18
1:00 p.m.	Southwest	50	90	15
2:00 p.m.	Southwest	45	85	13

3:00 p.m.	Southwest	50	90	11
4:00 p.m.	Southwest	45	85	9
5:00 p.m.	Southwest	40	65	7
6:00 p.m.	Southwest	30	55	5

NEW OFFICIAL FUJITA SCALE

As a final note, we wish to point out that the Fujita scale used to determine tornado intensity is being revised and a new official version of the scale will be used by the National Weather Service beginning in 2007. One of the most significant changes being made is to adjust downward the strength of wind required to significantly damage or destroy a home. This change is based on years of research and experience in the field. The following table lists the range of wind speed expected to cause varying degrees of damage to a residence. A range is used to account for variations in the quality of construction, with the lowest speed for each category applicable to poor construction and the highest speed relevant for high quality construction. We should point out that this scale is designed for tornado damage, which usually takes place in a matter of seconds. The relentless pounding by hurricane winds over a period of hours would further lower the wind threshold required to cause these levels of damage.

DAMAGE DESCRIPTION	POOR CONSTUCTION (MPH)	AVERAGE CONSTRUCTION (MPH)	BEST QUALITY CONSTRUCTION (MPH)
Threshold of visible damage	53	65	80
Loss of less than 20% of roof covering, gutters, awnings; loss of siding	63	79	97
Broken glass in door and windows	79	96	114
Uplift of roof deck and loss of more than 20% of roof covering; chimney collapse; garage doors collapse inward; failure of porch or carport	81	97	116
Entire house shifts off foundation	103	121	141
Large sections of roof structure removed; most	104	122	142

walls still standing			
Top floor exterior walls collapsed	113	132	153
Most interior walls of top story collapsed	128	148	173
Most walls collapsed in bottom floor, except small interior rooms	127	152	178
Total destruction of entire building	142	170	198

CONCLUSION

Hurricane Katrina brought devastation to the entire Mississippi coastline on August 29, 2005. At 421 East Beach Drive, Ocean Springs, Jackson County, Mississippi, the wind gradually increased during the late evening of August 28 and the first six hours of the 29th, accompanied by periods of very heavy rain. Then, between 6:23 a.m. and 6:43 a.m., four intense convective cells moved from east-southeast to west-northwest across 421 East Beach Drive, bringing torrential downpours and strong wind gusts. A fast-moving tornado caused by one of the cells swept across the property during the 20-minute period, producing wind gusts to between 150 and
200 MPH. The tornado caused severe damage to homes and trees in the neighborhood and carried a small car from the garage at 421 East Beach Drive to a wooded location between 0.1 and 0.2 of a mile to the northwest. At this time of the morning, no storm surge had yet affected the property.

After the tornado passage, the storm continued to rage. Wind damage continued to occur with gusts to between 95 and 125 MPH for the next four hours or so before easing a little late in the morning. The elevation of the storm surge increased at a rate of 3 to 4 feet per hour from 7:00 a.m. on until reaching a damaging peak height of approximately 22 feet at about 11:00 a.m. Both the wind speed and the storm surge began to drop during the last hour of the morning, with this trend continuing throughout the afternoon. Little or no additional damage occurred after mid-afternoon.

Our research clearly shows that the most severe wind gusts struck 421 East Beach Drive well before the arrival of the damaging portion of the storm surge. The most damaging winds occurred with the tornado prior to 7:00 a.m. on August 29 while the rapid rise in the elevation of the storm surge water began after this time and the surge did not peak until approximately 11:00 a.m

The conclusions in this report are based on currently available information. We reserve the right to modify this report in the future if new information becomes available that would materially change our findings.

The information in this report has been determined from the best sources of weather information available to us at this time and is the result of interpretation by our staff of professional meteorologists and represents our opinions to a reasonable degree of scientific certainty.

We trust that this information is useful to you. If you should have any additional questions or need additional information, please do not hesitate to contact us.

Sincerely,

Joseph P. Sobel

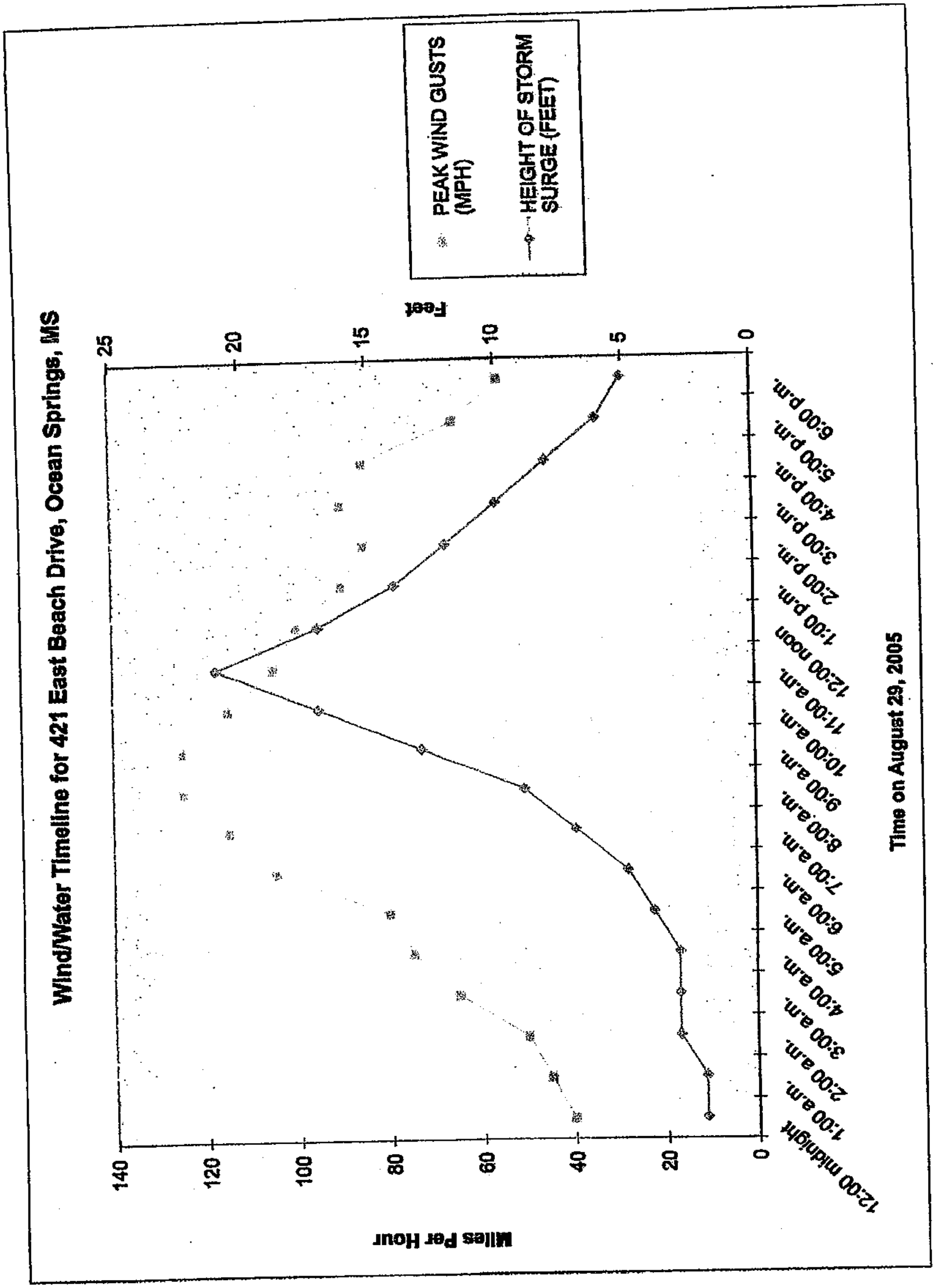
Joseph P. Sobel, Ph.D.
Director of Forensic Services

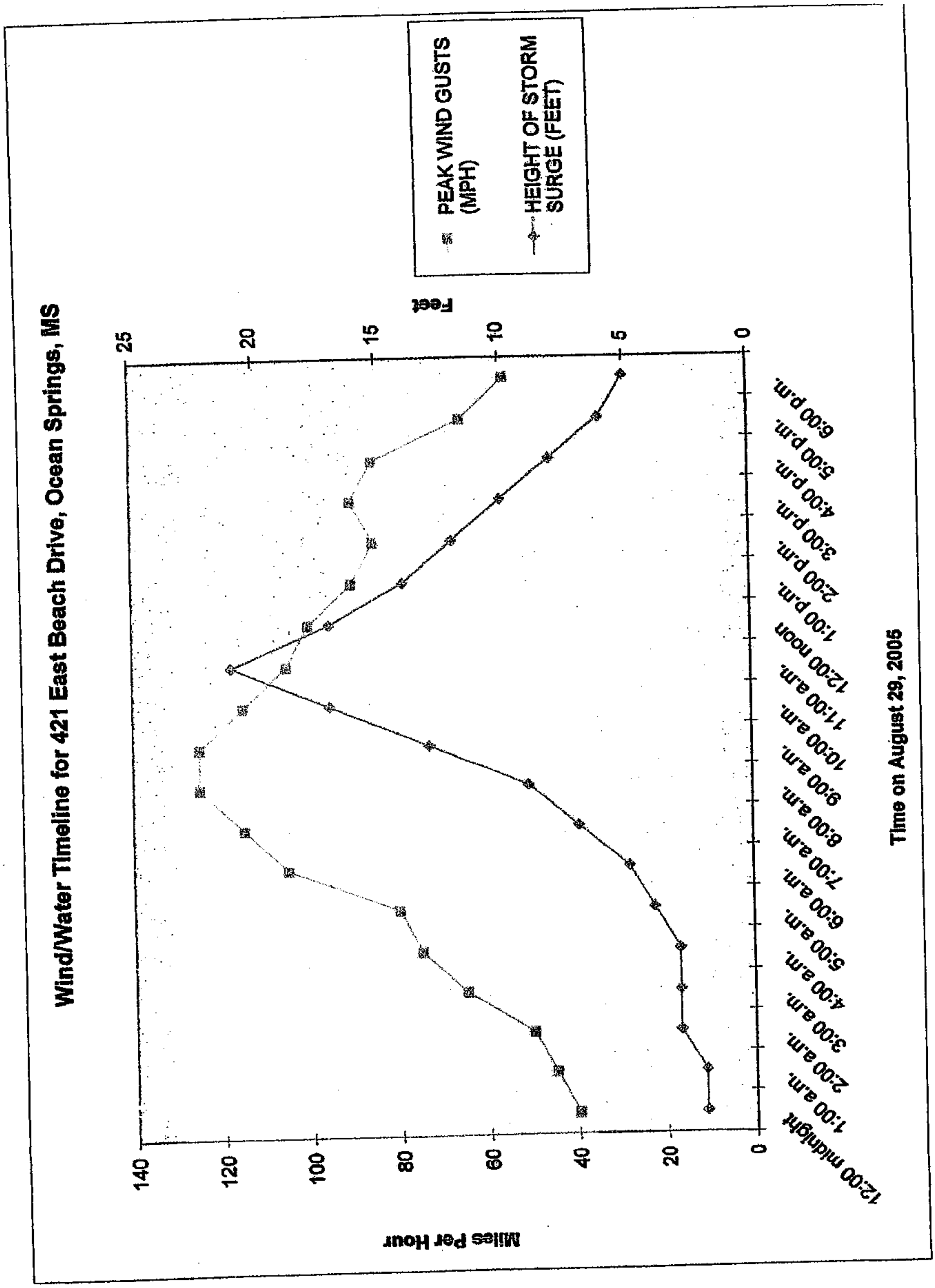
Stephen M. Wistar

Stephen M. Wistar
Certified Consulting Meteorologist

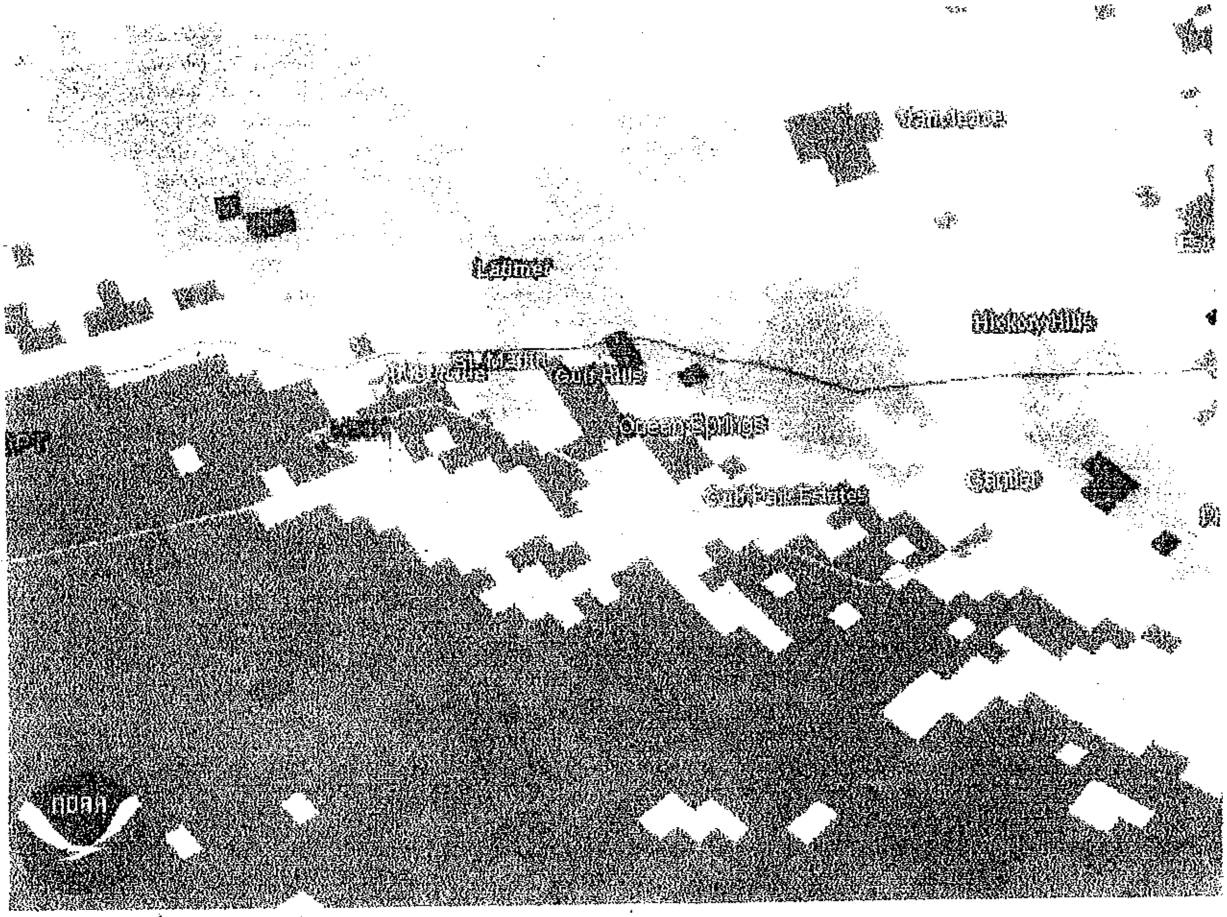
JPS/SMW:amb

Sheet2 Chart 1




Wind/Water Timeline for 421 East Beach Drive, Ocean Springs, MS
PEAK WIND GUSTS (MPH)
HEIGHT OF STORM SURGE (FEET)
Miles Per Hour
0
20
40
60
80
100
120
140
Feet
0
5
10
15
20
25
12:00 midnight
1:00 a.m.
2:00 a.m.
3:00 a.m.
4:00 a.m.
5:00 a.m.
6:00 a.m.
7:00 a.m.
8:00 a.m.
9:00 a.m.
10:00 a.m.
11:00 a.m.
12:00 noon
1:00 p.m.
2:00 p.m.
3:00 p.m.
4:00 p.m.
5:00 p.m.
6:00 p.m.
Time on August 29, 2005

7/25/2006



BASE REFLECTIVITY
KMOB - MOBILE, AL
08/29/2005 11:49:03 GMT
LAT: 30/40/44 N
LON: 88/14/23 W
ELEV: 289.0 FT
MODE/VCP: A / 121

ELEV ANGLE: 0.50 °
MAX: 53 dBZ

Legend: (Category) dBZ

(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5

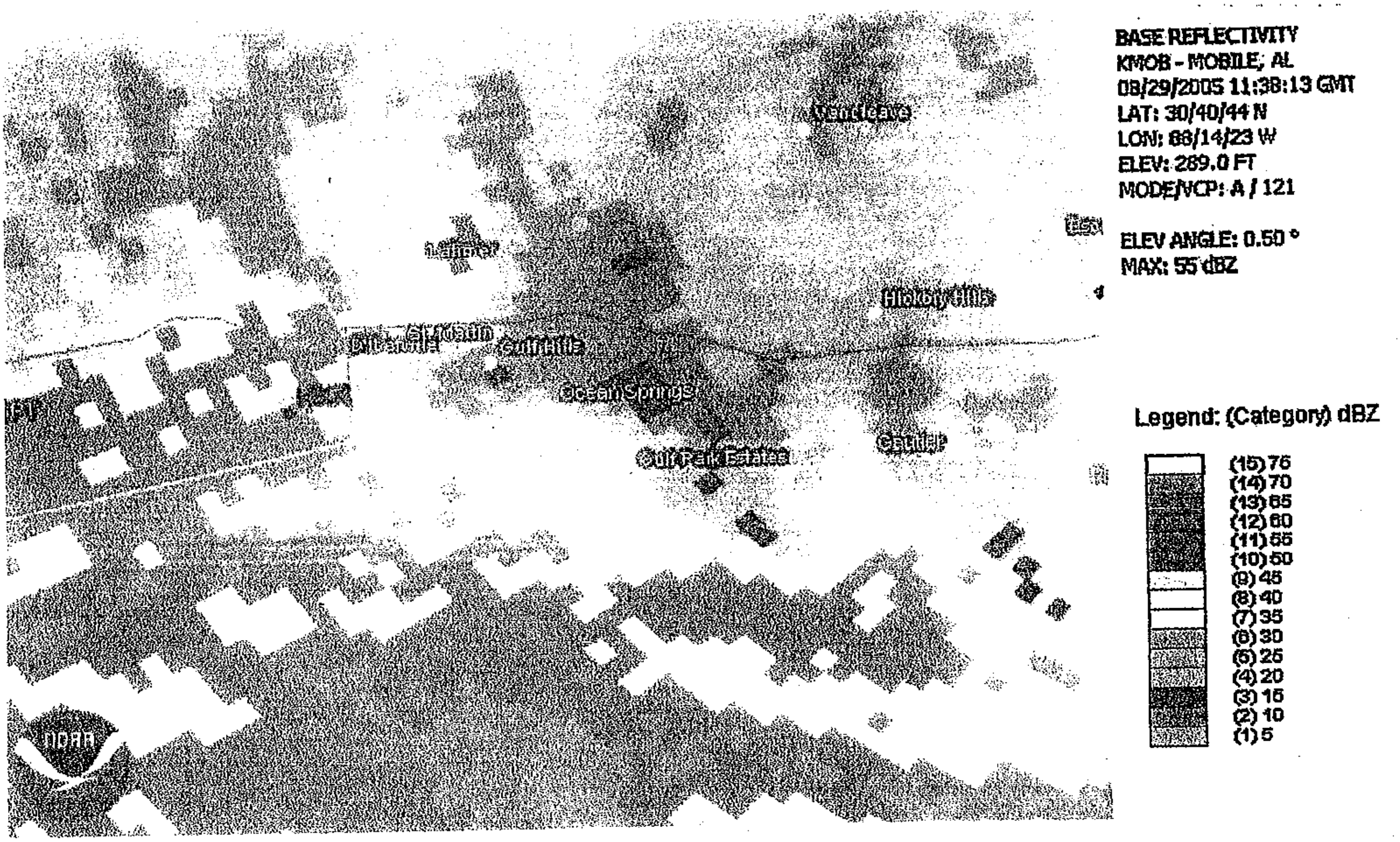
BASE REFLECTIVITY
KMOB - MOBILE, AL
08/29/2005 11:22:02 GMT
LAT: 30/40/44 N
LON: 88/14/23 W
ELEV: 289.0 FT
MODE/VCP: A / 121

ELEV ANGLE: 0.50 °
MAX: 54 dBZ

Legend: (Category) dBZ

(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5

7/25/2006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LON: 88/14/23 W
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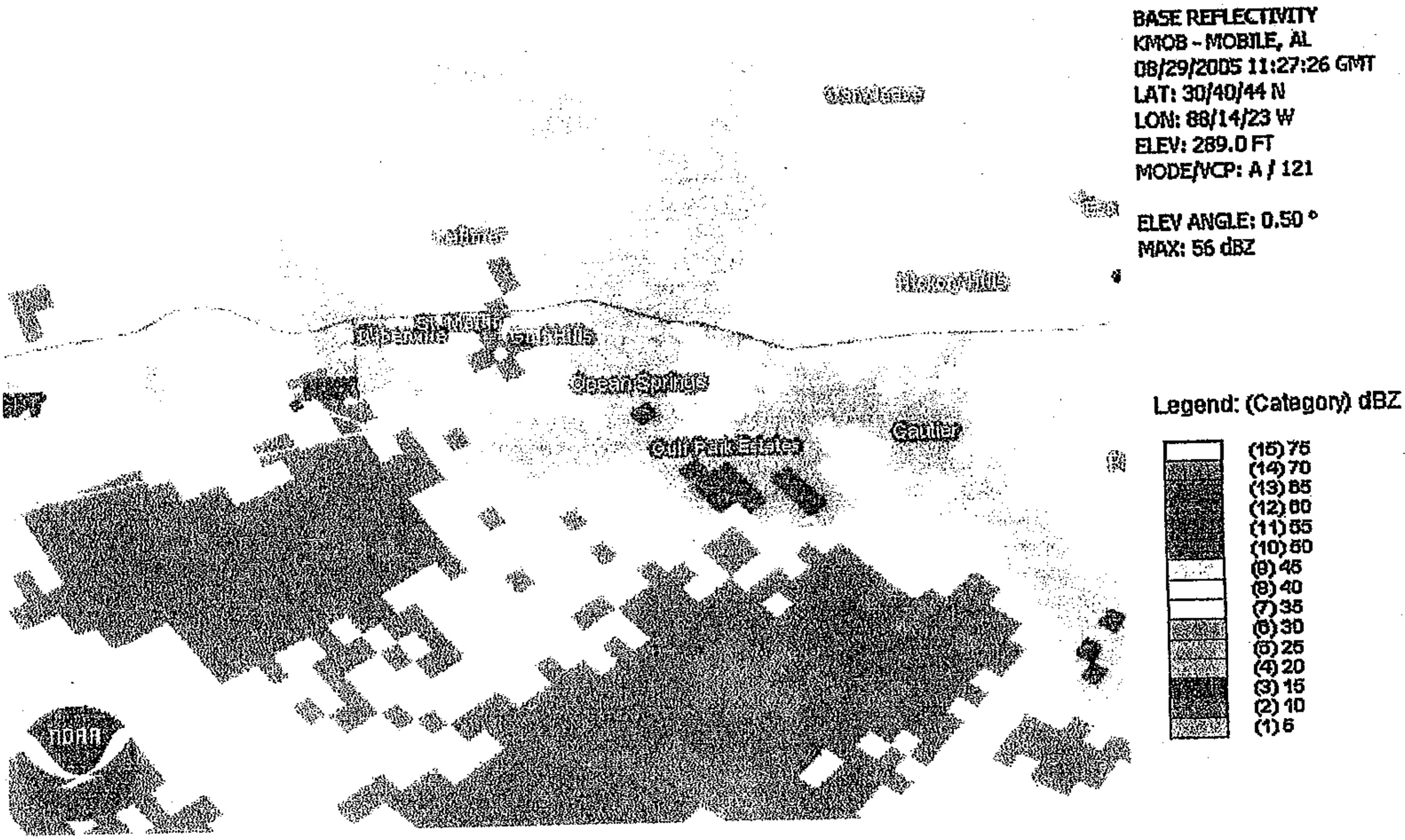
MODE/VCP: A / 121
ELEV ANGLE: 0.50 °
MAX: 55 dBZ
Legend: (Category) dBZ
(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5
Vancleave
Hickory Hills
Ocean Springs
Gulf Park Estates
Gautier
NOAA


BASE REFLECTIVITY
KMOB - MOBILE, AL
08/29/2005 11:43:38 GMT
LAT: 30/40/44 N
LON: 88/14/23 W
ELEV: 289.0 FT
MODE/VCP: A / 121
ELEV ANGLE: 0.50 °
MAX: 54 dBZ
Legend: (Category) dBZ
(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5
Latimer
Hickory Hills
St. Martin
Gulf Hills
Gautier
NOAA

7/25/2006

7/25/2006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08/29/2005 11:27:26 GMT
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LON: 88/14/23 W
ELEV: 289.0 FT
MODE/VCP: A / 121
ELEV ANGLE: 0.50 °
MAX: 56 dBZ
Ocean Springs
Gulf Park Estates
Gautier
Legend: (Category) dBZ
(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5
NOAA


BASE REFLECTIVITY
KMOB - MOBILE, AL
08/29/2005 11:32:50 GMT
LAT: 30/40/44 N
LON: 88/14/23 W
ELEV: 289.0 FT
MODE/VCP: A / 121
ELEV ANGLE: 0.50 °
MAX: 54 dBZ
Latimer
Hickory Hills
St. Martin
Gulf Hills
Ocean Springs
Gulf Park Estates
Gautier
Legend: (Category) dBZ
(15) 75
(14) 70
(13) 65
(12) 60
(11) 55
(10) 50
(9) 45
(8) 40
(7) 35
(6) 30
(5) 25
(4) 20
(3) 15
(2) 10
(1) 5
NOAA

7/25/2006